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Hydraulic-Fill Dams.

There is no line of engineering construction which exhibits a more rapid progress during the past few years than that of earth dams. The general type of earth dams is old; indeed, it is one of the most ancient constructions, although formerly of but small height and crude details. The creation of great reservoirs for modern waterworks and irrigation purposes has demanded the design and construction of correspondingly high dams, and it is interesting to observe that until comparatively recent times only the masonry structure was considered the proper type for such works. In fact, the eminent consulting engineers retained by the New Panama Canal Co. for the construction of the proposed earth dam at Bohio on the line of the Panama Canal, stated that a greater height of earth dam than about 75 ft. could not be considered prudent, and their recommendations for that structure were made accordingly. Furthermore, what may be considered standard modern earth dam construction requires a careful selection of material placed in layers of correct thickness and consolidated with grooved rollers or their equivalent. Any radical deviation from this method of procedure or resort to the earth type for heights even greater than any reached by masonry structures would have been considered dangerously heretical in most quarters until very recently.

Various developments, chiefly in hydraulic mining, have fundamentally changed the older views within a remarkably short time. Actually accomplished works justify the adoption in certain cases of novel procedures and conclusions of the greatest practical importance. In the October "Proceedings" of the American Society of Civil Engineers there will be found a paper on "Recent Practice in Hydraulic-Fill Dam Construction," by James D. Schuyler, of unusual interest in this connection, as setting forth the chief features of a number of dams already built by the hydraulic-fill method, as well as others in process of construction of great height, two of which, 175 and 190 ft. high, are to serve the corporation supplying electric light and power to the city of Mexico.

There are several features of the hydraulic-fill method which are to be observed as among the most important. In the first place, the amount of water required is, or might be, relatively small, for by a proper arrangement of the plant and works, the same volume is used in a continuous circuit, so to speak, requiring only so much replenishment as may be needed to make up leakage, percolation and other similar incidental losses. In the second place, under proper regulation of the process, the deposition of material is not indiscriminate, for a simple but effective system of hydraulicing the portions of the aggregate material into different grades of coarseness or fineness is accomplished, as well as their subsequent distribution during deposition in such a way as to result in the most permanent and effective embankments. The finest material is so placed as to constitute a central puddled, impervious mass absolutely water-tight and protected, particularly upon its face, with the coarser graded materials, those of the larger size making up the outer slope. The main purpose of this part of the design is to make the interior third of the mass fine and water-tight. The other two-thirds form the protected portion of the finished embankment. The satisfactory accomplishment of these ends is not attended without some difficulty, the degree of control depending upon the results of intelligent experience. The tendency of the sandy material to settle in more or less pervious strata must be carefully watched and guarded against, as shown by Mr. Schuyler, but it is perfectly practicable to observe and control that tendency. He sums up the purposes of the method and the ends to be attained effectively, as follows: "The inner third of the dam should be composed of impervious material . . . which . . . should consolidate into a mass . . . and remain in a moist, semi-plastic condition; the outer half of each of the other thirds should be coarse, porous, open material through which water draining from the interior would pass freely; while the inner surface of the outer thirds should be a mixture of coarse and fine or semi-porous material in condition to act as a filter, so as to prevent the escape of any of the fine particles from the inner third . . ."

It is highly interesting to observe in connection with Mr. Schuyler's discussion of the general process which should govern the construction of earth dams, that he lays great stress upon the avoidance of any possible percolation through what may be termed the foundation mass of the structure. He insists that the dam "must be founded on an impermeable foundation and form a water-tight connection with the rock or clay bed on which it rests." This is eminently prudent and obviously involves only safe and sound engineering procedure, but it is apparently somewhat in contrast with the proposed use of the porous material filling the geological valley upon which the great Gatun earth dam of the high-level Panama Canal is to rest.

The volume of solid material carried in the water current for deposition in the dam naturally varies between wide limits and is affected by the coarseness or fineness of the material and the rapidity of the current. In some instances given, as high as nearly 48 per cent. was reached, and the average varied "from 32 to 38 per cent. for several weeks," showinng that the capacity of this hydraulic conveyance is, under proper conditions, certainly efficient. This obviously is one of the details of the method on which is chiefly based its effectiveness. In the cases considered, there were perhaps no conditions existing which tested perfectly the capacity of the method for lifting the solid material to any considerable height. At the same time a sufficient range of cases is given by Mr. Schuyler to justify the expectation that the effective range of the process may extend considerably beyond the limits which it has so far reached. The economy of the method under proper demonstration is obvious, and if its mechanical efficiency is high enough to enable it to be applied to lifts of considerable height it will certainly find a widely extended application in the construction of large dams in the future.

The Economics of Hydro-Electric Plants.

In the issue of this journal of October 20th there was a paper by Dr. Perrine, on load factors, which will profitably bear much consideration. Every engineer is familiar enough with the broad fact that it is uneconomical to handle small load upon a large plant, but the application of this principle to hydro-electric plants leads to conditions somewhat different from those met in steam driven stations, and it was to these modifications that Dr. Perrine directed attention. The fundamental fact that faces the engineer of a hydro-electric plant is that the total amount of hydraulic power available is once for all a fixed quantity. Of the rain that falls in the drainage area of the stream a certain proportion finds its way into the stream, and that is all that is there available. Taking a series of years, too, the distribution of this available water through the year is approximately uniform so that one can say broadly that the total normal power is, for instance, 5,000,000 kilowatt-hours per year, and that its distribution through the year follows a certain power curve. In some streams this curve is very regular; in others extremely irregular, showing torrents at certain seasons and rivulets at others. The task of the engineer is to take the power curve and do with it the best he can in earnings, attacking the problem with all the resources at his command. If the power curve is a straight line parallel to the axis and a perfectly uniform load can be obtained then the coefficient of utilization is unity. But the same condition holds for every case in which the power curve and the load curve can be made to coincide, and from the commercial standpoint there may be much to choose between these various particular solutions of the problem.

For instance, the one case can be represented, as suggested by Dr. Perrine, by an electrochemical works running every day in the year at uniform load and deriving power as at Niagara from a tunnel running full every day in the year. On the other hand one might imagine a yearly power curve which, granting merely day storage, would coincide with the annual curve of lighting demand and which might be used exclusively in lighting. Of the two plants the latter would quite certainly be by far the more profitable, so that extreme uniformity in load is not necessarily more advantageous than a manageable irregularity. Given a particular power curve, the engineer must try either to make his load fit it or to fit it to his load. Upon the whole, a fairly uniform load requires less investment in machinery than a variable one, but to secure uniformity may cost heavily. So far as the power curve goes, it can be built up toward uniformity by careful attention to storage or by the use of an auxiliary plant. The chance of the former is always worth investigation. Storage for time enough to level if need be the fluctuations of the daily power curve is almost a necessity. Storage for longer periods against the annual power curve is important, but oftentimes impracticable or prohibitive in cost. In any case, the problem of storage cannot be properly settled except by reference to the load curve possible in the place considered. To build this up into any required form is no easy task, for it has, like the power curve, a prevailing shape not easy to change save in detail. As Dr. Perrine pointed out the customer with a large uniform demand who can take full advantage of a "maximum demand" rate is generally a rather unprofitable customer, and if all the business were of this class the central station would find pretty poor pickings in most places.

Getting a good income, then, depends on the success with which the details of the load can be governed, and this is a matter of infinite finesse. The older hydraulic power companies carried out a plan which hydro-electric plants have sometimes followed, of dividing the total power into classes sold at different rates. "Permanent" power represented the certain flow of the stream and commanded the highest price. "Non-permanent" power came next, representing the difference between permanent flow and high water conditions, and then came "surplus" or other tertiary supply. Hydro-electric plants can and do sometimes sell "non-permanent" power, but most industries are so run that they simply must have power at particular times, and "non-permanent" supply is relatively of small value to them. On the other hand, if the load can be skilfully built up the "non-permanent" power is as valuable as any other. It is in this particular that auxiliary steam or gas engine plants find their most profitable use. By furnishing, for instance, 1,000 kilowatt-hours per day from an auxiliary at a production cost of, say, 3 cents per kilowatt-hour, one may be able to sell not only this at, say, 4 cents, but also 2,000 kilowatt-hours of hydraulic power costing, say, only a cent per kilowatt-hour. A certain valley in the load curve cannot be brought up, in other words, without lifting the crest of the load curve over the top of the power curve, save by the help of an auxiliary. Any industry that requires power mainly at unusual hours is a boon to the supply station, and is far more worthy of encouragement than a load, however steady, that adds to the peak. There have been so many solemn theories about "scientific" and "logical" rates that people have well nigh forgotten that net earning power is the thing sought. Many a plant has saddled itself at the start with a big block of power at cut rates which could have been sold at double the price a few months later. Laying out a plant for earning capacity is a fine art which deserves to be cultivated, even to the exclusion of more regular and canonical methods.

A New High-Duty Engine Record.

A new record for high duty has just been made at the Wildwood pumping station of the Pennsylvania Water Co., at Nadine, Pa., by a vertical, cross-compound, condensing pumping engine, for the test results reached 157,394,107 ft.-lb. per 1,000 lb. of dry steam. These figures indicate very clearly the great importance of adjusting pumping machinery to the conditions to be met, as opposed to emphasizing any one or a few particular factors. In this case, a happy combination of several leading factors has placed this engine in the lead, and in fact very close to the front line of possibilities in expanding steam through two cylinders, so far, at least, as pumping water is concerned. The engine was built and installed by the Allis-Chalmers Co., and has the Reynolds-Corliss steam end and the Riedler method of operating the pump valves by mechanical means. The test for duty was conducted by Mr. Charles A. Hague, M. Am. Soc. C. E., and from the report made by him to the water company, very complete data and information may be obtained.

The range of temperature in the high-pressure cylinder was 127°, and in the low pressure cylinder 62°. Of the total steam used by the engine, 9.9 per cent. was sent through the steam jackets and reheater coils, a very low record. The revolutions per minute were 67.86, and the piston and plunger speed average 544 ft. per minute, a very high record for pumping engines. The total head pumped against was 615 ft., including suction and friction; and the steam gauge pressure at the throttle was 176 lb.; the rate of pumpage was a little over 10,000,000 gal. per 24 hours, the contract capacity of the machinery. As an indication that high piston speed alone is not all important regardless of other things, it will be well to note in passing that the highest duty record is 15 per cent. above the performance of this engine, and was made by a triple expansion machine, at 18 revolutions and 198 ft. piston speed per minute.

The general design follows the lines of the regular pumping engine practice of this builder, as regards the outside packed plungers, the connections from main cross-head to plunger head, plunger and valve chambers, framing, bed plates, arrangement of shafts, connecting rods, etc. The departing elements from the regular practice for pumping machinery are a rather high piston and plunger speed, both in revolutions and feet per minute, and the mechanically operated pump valves, but there are no good reasons apparent for believing that a rate of speed which would allow the use of the ordinary automatically or naturally operated pump valves would not produce as good results when combined with an equally good adaptation of steam end to surrounding conditions.

As a machine adapted to its work, the design is not particularly striking in mere form and arrangement of parts, as these are such as have been often seen. But it is a fortunate and clever application of proportions and dimensions with regard to steam pressure, water pressure, relation between high and low pressure cylinders, so as to produce practically a balance of power between the two steam pistons, an extremely close and economical adaptation of steam jacket and reheating facilities, and other factors which, although vital enough in themselves under ordinary situations, are greatly magnified in value when so related to each other that all may be utilized by the engine to the best advantage in meeting the actual working conditions imposed.

The steam cylinders are 25 in. high pressure and 60 in. low pressure, with a stroke of 48 in., and with the induction and exhaust valves placed across the cylinder heads so that the clearance at the cylinder ends is brought down to the lowest practicable amount. The annular spaces for the steam jackets are formed in the usual manner in this type, and the reheater is liberal in proportions and provided with two heating coils arranged so that either one or two coils may be used at pleasure. The percentage of the total steam used in the steam jackets and reheating coils was kept down nearly to 9 per cent., and was almost equally divided between the jackets and the coils. The excellent condition of the working steam is indicated by the fact that the ratio of steam expansion by volumes was only about 3 per cent. less than the ratio by pressures, the difference being easily accounted for by the slight drop in pressure at the end of the high-pressure diagram, showing that the receiver pressure was not maintained quite up to the high-pressure terminal. The steam pressure was about 184 lb. absolute at the point of actual cut-off in the high-pressure cylinder; while the low-pressure terminal at the point of release was 8.8 lb. absolute; the absolute pressure in the exhaust pipe was 1.7 lb. about 6 ft. away from the low-pressure cylinder outlet, the vacuum showing at the same point 26.5 in. by a mercury column, and the temperature was 118° Fahr.

The steam consumed by the engine and its appurtenances for duty calculations was taken as the weight of the condensed steam delivered by the air pump from the surface condenser, the weight of the condensed steam rejected by the reheater coils of the receiver between the high and low-pressure cylinders, and the weight of the condensed steam rejected by the steam jackets of the engine, plus any amount observed as leakage or loss before the condensed steam reached the weighing barrels, and plus the amount of steam used by the independent air compressor furnished with the engine and necessary for the successful operation of the main pumping engine. The work done by the engine against which the steam consumption was charged, was taken as the weight of the quantity of water displaced by the plungers, multiplied by the head in feet represented by the total load observed and averaged during the test run.

The pump horse-power was 1,151.77 and the indicated steam horse-power was 1,199.41, giving a mechannical efficiency in the machine of 96.08 per cent. The energy indicated by the high-pressure cylinder was 605 h.-p., and that of the low pressure 594 h.-p., showing remarkably close balance in power between the two elements, in fact a trifle over 1 per cent. apart, no doubt as close together as indicators could be adjusted if the opportunity were offered for attempting an absolute balance.

The Riedler pump valves are operated by means of valve arms and eccentric connections, taking motion from one of the main eccentrics which actuate the steam valve gear; and a very economical and effective design utilizes the eccentric work to such a complete extent that only two eccentrics are required for the motions of all of the valves of the engine, including all of the steam and water valves.

There seem to be two important mechanical features in this engine running at such high speed which contribute to its good work. One is the extension of the heavy main crank shaft the entire length of the machine and with double cranks beneath each cylinder, thus stiffening and thorough-bracing the construction while under stress. The other is the application of air-compressing cylinders beneath the steam cylinders and in the line of motion of each plunger. These air cylinders are fitted with pistons similar to steam pistons which bring the imprisoned air up to a balancing pressure at the instant of reaching the top center, against the moving parts and the water column, without the use of weights which, at such a high speed, would no doubt give out considerable energy just when not wanted.

This pumping engine is described as exceptionally heavy and strong in proportion to its work, and the record shows that its work is unusually severe as water works practice is found. The machine apparently handles its load with perfect ease, and so far as the engine itself is concerned with great smoothness. But the main pump valves, in common with others of this type, are clearly in evidence by the sound of their closing, which is very pronounced. Of course it is practically impossible to operate large pump valves under rapid motion and heavy pressure, opening and closing in 0.22 second, either naturally or mechanically, without considerable sound when they are seated, but when it is considered that the engine, as the station records show, has been operated for more than a year with an extremely small amount of attention to the main pump valves having been necessary, so far, at least, there is no fault to be found. What the final outcome regarding the pump valves will be, time only can tell. There is nothing unpromising at present, and the verdict seems to be that their case is unproven, with the evidence in their favor, but it will be good business policy to charge at least double depreciation against this engine pending future possibilities, for a few years, until its real status is known beyond a reasonable doubt. From the investment point of view it will require some investigation to ascertain its commercial standing when compared with the class of pumping engine which holds the actual high duty record some 15 per cent. above. This cross-compound costs $14 per million foot gallons, while the best class of triple costs $20 upon equal terms of power; but the latter will earn 5 per cent. on $33,000 by better steam economy, with the repair account so far in favor of the triple, upon an equal horse-power with this compound engine even at its new high-duty record.

Notes and Comments.

A Covered Channel, 32 ft. wide and 23 ft. high of Δ-section, is under construction at Newcastle-on-Tyne, in order to furnish a course for a small stream flowing through a valley which will be filled to a considerable depth. This channel is 2,100 ft. long and has reinforced concrete walls 8 in. thick at the crown and 14 in. at the springing.

Sewage Irrigation has been carried on successfully for ten years at Vassar College, at works designed by Mr. Allen Hazen and the late A. F. Noyes. The outfall sewers lead first to a pair of 2-acre filter beds and then to the outlets to the irrigation field. The two beds are used alternately whenever the field is out of commission more than four weeks at a time, as between planting and harvesting and during very cool weather. Silo corn is raised, and the yield of the land has been steadily increasing. Some interesting records of the system were given some time ago in a paper by Mrs. Ellen H. Richards and Mr. George W. Moulton before the Sanitary Section of the Boston Society of Civil Engineers, and show what can be accomplished by irrigation when the soil is suitable and the work is done intelligently.

Heavy Locomotives of the Mallet compound type seem to be attracting unusual attention from trunk lines just now. The Baltimore & Ohio R. R. has had one in operation for some time, with much reported success, although no orders for more like it have apparently been placed. The Great Northern Ry. has ordered three from the Baldwin Locomotive Works for use on steep mountain grades. Each of these engines will weigh 355,000 lb., of which 316,000 lb. will be on the drivers, and will have a tractive power of 71,600 lb. The Erie R. R. will receive next spring from the American Locomotive Co. three locomotives of this type, each weighing 410,000 lb., carried wholly on sixteen driving wheels. These enormous locomotives will have a tractive capacity of 98,000 lb., and are to be used in hauling 2,000-ton trains on the heavy grades and curves between Hornellsville and Susquehanna.

The Average Wages per hour paid in 1905 in 349 occupations in 4,121 establishments were 18.9 per cent. higher than those paid in 1890-99, inclusive, and the average hours of labor per week were 4.1 per cent. lower. The average wages per week in 1905 were 14 per cent. higher than in the same ten-year period, and the total payroll was 52.3 per cent. higher. These figures were recently made public by the U. S. Bureau of Labor, which also states that the retail price of the principal articles of food, weighted according to their consumption in the family, was 12.4 per cent. higher in 1905 than in 1890-99. Therefore the purchasing power on an hour's wages in 1905 was 5.8 per cent. greater than in 1890-99, and of a week's wages 1.4 per cent. greater, the difference between the weekly and hourly figures being due to the reduction of the hours of labor that has taken place lately.

A Landslip at the Boone viaduct of the Chicago & Northwestern Ry. has been stopped by an extensive system of underdrains. It occurred on one side of the valley and seriously threatened the stability of some of the piers of this important structure. The sliding took place about 8 ft. below the surface in a sheet of dark red clay about 1/16 in. thick between two layers of blue clay. The remedy devised by Chief Engineer Carter was to construct three deep drains, with numerous branches, running downhill at an angle of 37½ deg. with the bridge. The main ditches were 5 ft. wide on the bottom, and varied in depth from 4 ft. at the lower end to 10 ft. at the upper end; they had a collective length of 950 ft. and had seventeen branches of the same size as the main ditches. All were filled to a depth of 3 ft. with one-man stone, which was covered with 2 ft. of willow brush to support the backfilling.

Blasting in a Business Street, during business hours, and without injury to property or serious inconvenience to the public, has been accomplished by the United Railways Co., of St. Louis, in connection with the removal of the old concrete cable conduit on Olive St. The tracks are double, and one was blown up at a time, the cars being operated on the other without much difficulty. The fact that the concrete under one track was separate from that under the other simplified the problem. The blast holes were made with a pneumatic drill and a motor-driven air compressor mounted on the construction car. Ten-foot sections of the track were blasted at one time. Flying debris was prevented from doing damage by means of a "cover car," which was simply an ordinary flat car heavily planked with 6-in. ties and provided on all sides with heavy hanging curtains of oak. This was run over the blast before it was fired. Only a few window panes were cracked by the concussions. The blasting and moving of the debris to one side was done by six crews of about 50 men each, three night and three day gangs. These men tore up about 20 blocks of single track in 24 hours.

An Air-Tight Boiler Room proved to be the solution of a problem due to the use of a chimney of entirely inadequate area. The room was very small and without any means of ventilation. The 248-h.-p. boiler, of the water-tube type, had a smoke opening of 26¼ in. by 9 ft., while the dimensions of the stack were 19x19 in. Forced draft, applied under the grates, was out of the question, since the gases would then be forced out through the fire door into the boiler room and the fire front and doors would soon be destroyed by the flames. Induced draft was equally impossible because of lack of space in which to place a blower. It was finally decided to make the boiler room air-tight and force air into it with a steel plate fan 4 ft. by 22½ in. The result of this procedure was that the room was made cooler and the fire burned as might be expected with a good stack having a draft of ¾ in. No gases escaped into the room. The installation, while it operates very satisfactorily, is not regarded by its designer, Mr. G. T. Hanchett, as a permanent arrangement, and will in time be improved by the construction of a new stack.

Electric Towing Locomotives are used on the Teltow canal in Prussia. The motors and other machinery are mounted on a long, low, steel framework, supported at one end by two wheels and at the other by a four-wheel truck. A series motor is geared to each of the two axles of the truck. Each motor develops 8 h.-p. when running at 800 r. p. m. at 550 volts direct-current, with double gearing. The motors are covered with a cab which in turn is surmounted by the trolley pole. The cab end travels foremost. Over the single axle at the rear of the locomotive is placed the towing pole, built of steel in the form of a truss. It is attached at its lower end to an axle, and, by means of a 3-h.-p. motor, may be raised or lowered by swinging it about its axle. This makes it possible to raise the steel towing cable above boats tied along the bank and pass them without delay. The cable passes through a funnel at the upper end of the towing pole, and is then wound on a drum, also driven by a 3-h.-p. motor. This drum is attached to its axle by a friction clutch so adjusted that when the pull becomes more than about 2,500 lb. the drum revolves and allows the cable to pay out through the guide-ring on the end of the towing pole. This arrangement saves the motors from heavy pulls in starting a loaded boat. The locomotives operate on tracks of about 3-ft. 3-in. gauge, having rails weighing about 40 lb.

The Holding Power of Rail Spikes in wooden ties has recently been determined in an extensive series of tests conducted by the Forestry Service of the U. S. Department of Agriculture. The tests were made on ordinary commercial ties of loblolly pine, oak, chestnut and other woods, using common driven spikes, driven spikes of about the same form as the common spike but with lengthwise channels on the sides away from the rail, screw spikes of the American type, and screw spikes similar to those in use on European railroads. The common and the channeled spikes were driven into the ties in the usual manner to a depth of 5 in., while for the screw spikes, a hole of the diameter at the base of the thread was bored and the spikes screwed down to the same depth as the driven spikes. In the testing machine, the average force required to pull out common driven spikes varied from 7,000 lb. in white oak to 3,600 lb. in loblolly pine, and 3,000 lb. in chestnut. The holding power of the channeled spike is somewhat greater, about 11 per cent. more force, or 4,000 lb., being required to pull it from the loblolly pine tie. The two forms of screw spike were found to have about the same holding power, ranging from 13,000 lb. in white oak, to 9,400 lb. in chestnut, and 7,700 lb. in loblolly pine. An important difference was noted in the holding power of driven and screwed spikes in knots and in clear wood. Knots are brittle and lack elasticity, so that driven spikes do not hold as well in them as in clear wood; in the case of common spikes in knots in loblolly pine, the decrease of holding power amounts to about 25 per cent. On the other hand, screw spikes tend to pull out the whole knot which they penetrate, and this increases the resistance so much that in loblolly pine the holding power of screw spikes in knots is about 35 per cent. greater than that for clear wood.

THE QUALITY OF THE WATER SUPPLY OF CLEVELAND, OHIO.

By George C. Whipple, Consulting Engineer, New York.

In January, 1903, the city of Cleveland was visited by a severe epidemic of typhoid fever. The disease continued to be prevalent throughout the year. In February, 1904, it greatly increased in severity and continued until April, coming to an end only after a new water supply had been introduced. During the period covered by this long epidemic more than 6,000 cases of typhoid fever occurred in the city, making it one of the most important epidemics of the kind which has been known in this country; and had it not been for the timely introduction of a pure water supply it would have been appalling in its results. These serious conditions led to an extensive investigation of the quality of the water of Lake Erie in the vicinity of Cleveland on the part of the Water Works Division of the Board of Public Service, of which Prof. Edward W. Bemis is the superintendent. The investigation was conducted by the writer, and his report has just been made public by the Cleveland Water Department. The following is a resumé of this report:

Cleveland Bay and Water Supply.—The city is situated on an indentation of the southern coast line of Lake Erie, about one-third of the way from Toledo to Buffalo. The bay is about 40 miles long and 7 miles wide, and the city is situated at its deepest point. The water within the bay is nowhere deeper than 60 ft. and its average depth may be taken roughly as 50 ft. The bottom is chiefly fine sand and clay, but in some places there are deposits of mud, and in a few spots the bottom is rocky.

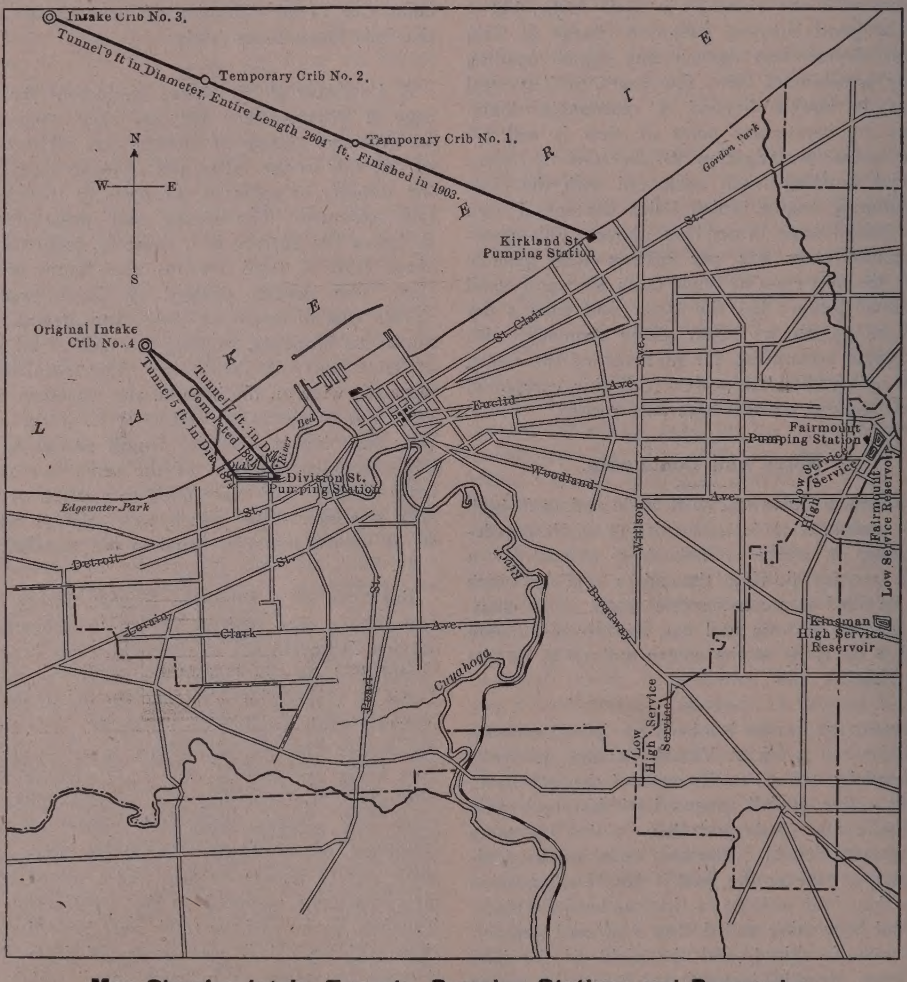
The Cuyahoga river flows into the lake through the heart of Cleveland, dividing the city into east and west sides. In front of the river mouth, and about a quarter of a mile from the shore, there is a breakwater which encloses the harbor. The breakwater has an opening opposite the river and a smaller opening in its westerly wing. These openings allow boats to enter and provide for the circulation of the water in the harbor. Inside the harbor and in the river dredging is going on almost continuously during the open season in order to keep the channel free.

The water supply of the city is derived entirely from the lake. The old intake of the water works, known as the West Crib, was located about 1.25 miles from the shore and about one mile west of the mouth of the river. From this crib two tunnels extend to the Division St. pumping station on the west side of the city, where the water is pumped into the city mains. This system furnished the supply of the city for about twenty years, or until the spring of 1904. In order to supply a greater quantity and better quality of water, new works were begun in 1890 and completed in 1904. They consist of a steel crib 4 miles from the shore opposite the mouth of the river, known as the East or New Crib, and a 9-ft. tunnel, which extends in a straight line to a pumping station on the shore of the lake at Kirtland St., where there are pumps which have a combined capacity of about 90 million gallons per day. These works have furnished the supply of the city since April, 1904. There are two distributing reservoirs connected with the system, one of them being used for high service.

The chief local sources of pollution of the water of Lake Erie in the vicinity of Cleveland are (1) the city sewers which discharge into the river and along the water front, (2) the Cuyahoga river, (3) the Rocky river, (4) the shore wash and the stirring up of the bottom of the lake by the winds, (5) the dumping of dredged material, and (6) the accidental pollution from steamboats.

All of the sewage of the city goes directly or indirectly into the lake. It has been estimated that the sewage of about 225,000 people runs into the Cuyahoga river and that the sewage of more than 200,000 people empties directly into the lake along the water front. A system of intercepting sewers is in process of construction. When completed this will remove practically all of the sewage from the river and the water front opposite the city and carry it to a point about nine miles east of the harbor. It will be many years, however, before this system is fully completed.

Except in the case of the Cuyahoga river the quantity of sewage entering the lake is not sufficient to create currents setting out into the water which preserve their identity for any considerable distance from the shore. Apparently the dispersion of the sewage by the action of wind and wave begins near the shore line. This dispersion is materially influenced by its temperature as compared with that of the lake water. It is also materially affected by the presence or absence of an ice-sheet.


Intake Crib No. 3.
Tunnel 9 ft in Diameter, Entire Length 2604 ft. Finished in 1903.
Temporary Crib No. 2.
Temporary Crib No. 1.
N
W
E
S
L A K E E R I E
Kirkland St. Pumping Station
Gordon Park
St.
St. Clair
Original Intake Crib No. 4
Tunnel 7 ft. in Dia. Completed 1890
Tunnel 5 ft. in Dia. 1874
Old River Bed
Division St. Pumping Station
Edgewater Park
Detroit
Ave.
Euclid
Woodland
Ave.
Fairmount Pumping Station
Low Service
High Service
Fairmount Low Service Reservoir
Willson
River
Broadway
Kinsman High Service Reservoir
Lorain
Clark
Ave.
Pearl
St.
Cuyahoga
Low Service
High Service

Map Showing Intake Tunnels, Pumping Stations and Reservoirs.

The Cuyahoga river has a drainage of 805 square miles. Even in its upper reaches it is more or less polluted. As it flows through the city of Cleveland its course is tortuous and its flow sluggish. Its surface elevation changes according to the lake level, and the stream has been rightly termed a slack-water estuary. The amount of sewage discharged into the river is so great, its current is so slow and its volume so small, that the water is nearly always foul and ill-smelling. Besides sewage the river receives the waters from several small brooks which are, for the most part, highly polluted. Immense quantities of manufacturing wastes are discharged into the river or into these runs, prominent among these being the waste of crude oil from the Standard Oil Co. This oily matter spreads out over the surface of the water, giving it an offensive appearance and a bad odor; and, what is more important, it forms a film over the surface of the water, which prevents, to a great extent, the absorption of oxygen. As a result of the great amount of pollution that the river water receives and of this lack of oxygen, the stream during the summer is nothing more nor less than an elongated septic tank. The suspended matter of the sewage and manufacturing wastes, together with the sediment brought down from the upper portions of the watershed, settles in the lower reaches of the river and forms a thick, black mud. This decomposes, and in warm weather bubbles of gas may be seen rising through the water and breaking at the surface. When the river is in flood some of the mud is carried out into the lake, but it is only the severe freshets which scour the bottom of the river to any appreciable extent. It has been roughly estimated that the amount of suspended matter carried into the lake each year by the Cuyahoga river is 200,000 cu. yd. Most of this is transported during the spring freshets. During the flood of Feb. 22, 1904, it was estimated that this amount of mud was carried into the lake in a single week.

The mud in the river and harbor of Cleveland is polluted. Ordinarily it contains from 1 to 5 million bacteria per gram and shows the presence of B. coli in large numbers. The samples of mud invariably have an oily odor.

The pollution which the lake received from the Cuyahoga river has a more important bearing on the quality of the water supply of the city than the sewage discharge along the lake front, on account of the greater volume of the river. There is good reason to believe that at times the river flows as a well-defined current out into the lake. When the conditions are such that this current is directed straight towards the intakes the dilution of the sewage is less and the pollution of the water supply is therefore greater than would be the case if the sewage were discharged uniformly along the entire lake front.

The Rocky river, having a drainage area of 347 square miles, discharges into Lake Erie about six miles west of the city. This river receives only a small amount of direct sewage pollution.

Through the constant discharge of sewage, manufacturing wastes and other polluting substances into the lake for many years, the shores of the lake in front of Cleveland are unclean and the deposits along the shores are foul. When these deposits are stirred up through the action of wind and wave the suspended matter is carried out into the bay, only to deposit again when the water becomes quiet. The mud at the bottom of the lake has been gradually becoming polluted for greater and greater distances from the shore.

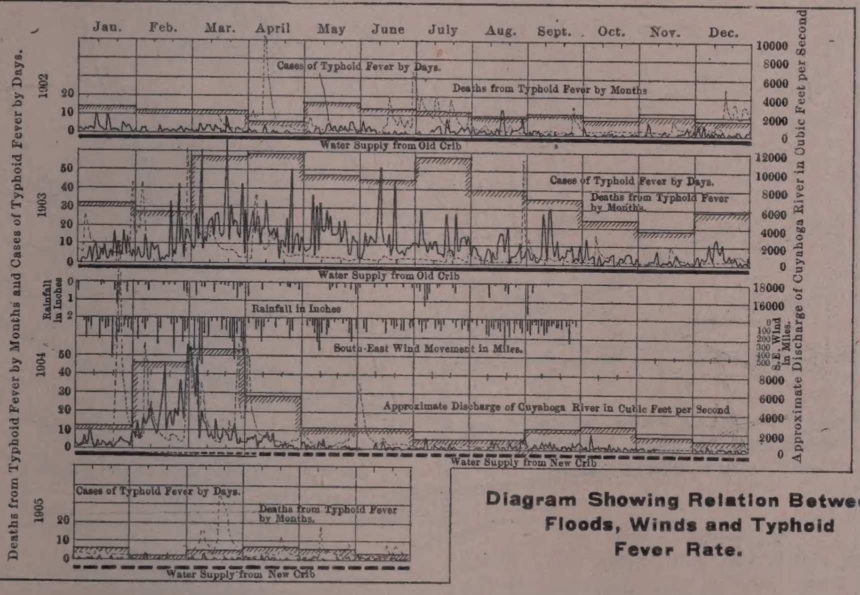


Diagram Showing Relation Between Floods, Winds and Typhoid Fever Rate.

The material dredged from the river and harbor has been dumped until recently into the lake at a point on the line of the new tunnel only 10,000 ft. from the new crib. The boundaries of this dumping ground were officially established by the United States Government a number of years ago. The effect of the dumping of polluted material from the river and harbor upon the quality of the city water was occasionally indicated by the analyses made during the summer of 1904. On June 4 an inspection showed that the water over the official dumping ground was covered with a thin film of oil, which spread out over a wide area. This oil came from the mud. A sample of water was collected near the float immediately after a scow had dumped, and a series of samples was taken at intervals of about a quarter of a mile in the direction in which the wind was blowing. The water had an oily odor for more than a mile from the dumping ground. The number of bacteria gradually decreased away from the spot, but the colon bacillus could be detected in all of the samples. Samples of mud collected from the dumping ground were found to be much polluted. Before the date when this inspection was made samples of the water pumped to the city had in a few instances distinct oily odors, and it had been observed that when such odors were present the water also contained the colon bacillus in small numbers. These conditions existed only when the wind had been blowing from the dumping grounds towards the crib. As a result of the investigations the United States War Department established a new dumping ground at a considerable distance from the water works intakes.

The steamers plying between Cleveland and various other cities on the lake pass within a mile or so of the water-works intake, and some of the fishing boats and scows often pass much nearer. The night soil of the city is carried out to sea in scows and dumped into the lake at a point eight or ten miles from the shore. These scows in their ordinary course pass within half a mile of the new intake. It is probable that the effect of accidental pollution from these boats is small, yet it is within the bounds of possibility.

The crib is used as a light-house, and this necessitates the constant presence of a keeper. At times also when repairs are being made several men may be employed at the crib for a number of days. A well-regulated system of disinfection and disposal of fecal matter at the crib is absolutely necessary under these conditions.

Typhoid Fever in Cleveland.—Typhoid fever has been prevalent in Cleveland for many years. The average death-rate for the thirty-two years from 1873 to 1904 was 52 per 100,000, with variations from 21 to 114. There is good reason to believe that a large part of this typhoid fever in the past has been caused by impure drinking water, which during this period was taken from Lake Erie at a point so near the city that, under certain conditions, it was inevitably contaminated with the city sewage. In order to demonstrate the relation between the occurrence of typhoid fever and the contamination of the city water supply, the statistics of the Health Department for the year 1902 were carefully analyzed. During this year there was rather less typhoid in Cleveland than usual, the death-rate being only 33 per 100,000; yet it was found that the typhoid fever followed the occurrence of conditions which tended to carry the sewage of the city towards the intake of the water works. Whenever the Cuyahoga river was in flood, and whenever at the same time the wind was blowing off-shore, thus tending to produce a fall in the lake level, the opportunities for contamination were greatly increased, and within a week or two thereafter there was an increase in the amount of typhoid fever in the city. These facts taken in connection with the erratic seasonal distribution of the disease were convincing evidence of the effect of the water supply on the health of the city.

The typhoid fever epidemic of 1903 began on Jan. 6, ten days after a heavy rainfall accompanied by brisk southeast winds. During that month and the first half of February new cases were reported at the rate of about ten per day; during the latter part of February the disease increased in severity, and through the months of March, April and May the severity of the epidemic was maintained. Throughout the summer new cases were constantly reported and often in very large numbers, and it was not until October that the disease subsided to normal proportions.

On Jan. 20-22, 1904, there was a severe flood at Cleveland. The rainfall amounted to 2.57 in., while the wind blew strongly from the southeast for several days. The discharge of the Cuyahoga river rose to more than 23,000 cu. ft. per second. Ten days after this flood typhoid fever began to increase and continued to do so until Feb. 10, when twenty-five cases were reported in a single day. On Feb. 6 and 7 another southerly storm caused a second flood in the river. This was less severe than the one previously mentioned, but meantime the sewage of the city had become thoroughly infected with typhoid bacilli, so that the effect of this second flood was more pronounced than that of the first. On Feb. 17 forty-seven new cases were reported in one day. Strong southeast winds occurred on Feb. 13 and again on Feb. 21, and in both cases were followed by more typhoid fever. During the last few days of February another southeast storm occurred; the discharge of the Cuyahoga river rose to 11,000 cu. ft. per second, while the lake level fluctuated considerably. The conditions were all favorable for a continuance of the epidemic, and the sewage at that time was probably more strongly infected with the bacilli of typhoid fever than at any other time during the preceding year. Again on March 25 there was another southeast storm which caused the discharge of the river to rise to 11,000 cu. ft. per second. Each of these storms would unquestionably have given the typhoid fever epidemic a new stimulus had it not been for the timely introduction of water from the new crib.

The introduction of water from the new intake took place as follows: The pumps at the Kirtland St. station were started on Feb. 10, 1904, and the pumps at the Division St. station were finally shut down on April 7. Between these two dates water was drawn from both intakes. Between Feb. 10 and 22 only a small amount of water was pumped at Kirtland St., but between Feb. 22 and March 1 about half of the water was drawn from each crib. Between March 1 and 15 three-quarters to five-sixths of the water was pumped from the new crib, and between March 15 and 31 about three-quarters was pumped from the new crib. Since April 7 all of the water has been drawn from the new steel crib except for a short time on July 21.

A study of the Health Department statistics showed that the typhoid fever decreased in steps which corresponded with the progressive increase in the use of water from the new intake. This is shown by the following figures:

AVERAGE NUMBER OF NEW CASES OF TYPHOID FEVER REPORTED DAILY.

Jan. 1-31, 1904, period prior to the epidemic caused by flood	2.84
Feb. 1-Mar. 5, period of epidemic corresponding to exclusive use of old supply	20.91
Mar. 6-15, period of epidemic corresponding to use of ½ of supply from new intake and ½ from old intake	11.10
Mar. 16-Apr. 21, period of epidemic corresponding to use of ¾ of supply from new intake	2.89
Apr. 22-Dec. 31, period corresponding to exclusive use of water from new intake	1.03

The epidemic practically ceased about the end of April, but a few cases of secondary origin occurred during May. During the summer of 1904 there was less typhoid fever in the city than in 1902, which was a favorable year, and much less than in previous years.

Since the introduction of the water from the new intake the typhoid fever situation in Cleveland has materially improved. Figures given in the report of the Board of Public Service showed that the typhoid fever death-rate during 1905 was only 15 per 100,000.

On the accompanying diagram will be found the fluctuations in the number of reported cases of typhoid fever from January, 1902, to June, 1905, together with lines showing the approximate discharge of the Cuyahoga River, the southeast wind movement, rainfall, etc.

Lake Erie as a Source of Water Supply.—In order to forecast the probable future sanitary quality of the water supply of Cleveland derived from the new crib, four miles off-shore, an extended series of investigations was carried out by the writer. These included studies of the movements of the water in Lake Erie, currents due to the wind, seiches, thermal currents, etc. These were taken up in connection with Lake Erie as a whole, but more particularly with reference to conditions in the Bay of Cleveland. An extensive series of analyses were made of samples of water collected on four parallel lines four miles apart at distances of 1, 2, 3, 4, 6, 8 and 10 miles from the shore. For the details of these studies reference must be made to the original report.

The water of Lake Erie does not move as a river from one end of the lake to the other, although there is a general eastward drift towards Buffalo. The effect of the wind greatly overbalances the general movement of translation and drives the water one way or the other according to its direction, velocity and duration. Temperature also influences these movements, and large streams have important local effects. There is a general eastward drift of the water in the middle of the lake, due chiefly to the effect of the prevailing westerly winds. The excess of wind movement down the lake is greatest during the winter months, but during August there is an excess of wind movement up the lake; taking the year as a whole there is an excess easterly movement amounting to an average of 67 miles a day. The friction of the wind blowing over the surface of the water produces a current in the same direction. Experiments made at Cleveland have shown that the surface movements of the water are somewhere between 3 and 7 per cent. of those of the wind above it. Assuming 5 per cent. as an approximate figure, it has been calculated that the average surface drift of the water down the middle of the lake is about 3.35 miles per day. Beneath the surface the induced velocity becomes less and less until at a certain depth other forces control the movements of the water. The easterly drift along the central axis of the lake tends to pile up the water at the east end, and to a less extent, on the concave shores on the Canadian side west of the three projecting points. This gives rise to return currents in a westerly direction along the shores and at the bottom, which currents seem to be more strongly defined on the Canadian than the American shore. Very little is known in regard to the return currents below the surface, but such bits of evidence as are available indicate that these occasionally occur.

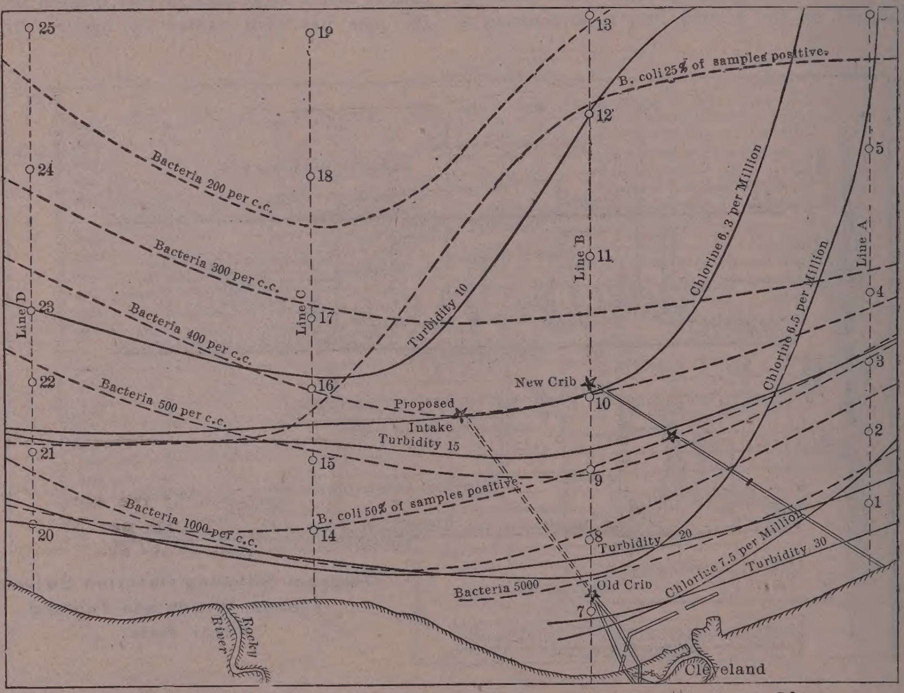
The winds blowing across the lake are much more nearly balanced than those blowing lengthwise, but they flucutuate much more rapidly. The lake breeze in the vicinity of Cleveland, which blows from the lake during the afternoon and towards the lake in the evening, tends to cause a diurnal movement of the water, but the effect of this breeze is often so slight that it is masked by the greater movement due to the seiches.

Seiches are oscillations of the water due to the piling up of the water on the lee shore, through the action of the wind or other cause; they consist of a series of rockings of the water of the whole lake about a nodal line passing through the center. The phenomenon is the same as may be observed in a basin of water when the water is disturbed slightly from one side to the other before coming to rest. The seiches of Lake Erie were carefully studied by Prof. A. H. Henry for the United States Weather Bureau. The data which he collected are reviewed by the writer in his report, and it is shown that the formula for the period of oscillation deduced from experiments in some of the Scotch lakes applies very closely to Lake Erie. This formula is as follows:

$$t = 2l \div 3{,}600 \sqrt{dg}$$

in which t is the time of oscillation in hours, l the length of the lake in feet, d the mean depth in feet along line of oscillation, and g the acceleration of gravity (32.16).

Assuming the length of Lake Erie to be 250 miles and the average depth of the lake to be 80 ft., the longitudinal oscillation is found to be 14.4 hours, which is in substantial agreement with the measurements made by Prof. Henry. The period of transverse oscillation was found to be 3½ hours. One of the most notable seiches ever observed in Lake Erie was that of the storm of Sept. 12, 1900. The wind maintained a velocity of 65 miles an hour for two hours which caused the eastern lake level to rise about 6 ft. above its previous elevation, while at the western end of the lake the surface of the water was depressed about 2 ft. Cleveland lies only a short distance west of the center of the longitudinal axis of the lake and consequently the fluctuations of lake level due to seiches are much less than at the extreme ends. Fluctuations greater than 1 ft. due to seiches are extremely rare at Cleveland. This is a fact which has an important bearing on the diffusion of sewage into the lake.



Curves Showing Quality of Water at Different Distances from Shore.

Studies of the Bay of Cleveland have shown that there are no well defined drift currents in that region, but that the currents are altogether variable and dependent upon the wind.

In common with other large bodies of fresh water vertical currents due to temperature occur in Lake Erie. This lake is a comparatively shallow one considering its size. Generally the water is in circulation from top to bottom, but during the period covered by the observations stagnation of the water opposite Cleveland was distinctly noticed at times, the depth of the thermocline being approximately 50 ft.

Quality of Lake Erie Water.—Some interesting studies were made of the general quality of the water in Lake Erie and of the other Great Lakes. Samples collected by Prof. Edward W. Bemis, between Cleveland and Duluth, showed that the hardness of the water and the chlorine, etc., increased gradually from the upper end of Lake Superior to Lake Erie opposite Cleveland. The chlorine studies which were made in Lake Erie were especially interesting and had an important bearing upon the interpretation of the analyses made at Cleveland. Chlorine is often used as an indication of pollution, and the fact that between the years 1887 and 1902 the chlorine had increased in the water supply of Cleveland from 2.77 to 11.68 parts per million, as shown by analyses made by Prof. A. W. Smith, was considered by some to be an indication of increasing contamination. To a certain extent this was no doubt the case, but investigation showed that much of the chlorine was due not to sewage pollution but to the salt water pumped from the gas wells in the northern part of Ohio. A series of samples of water collected between Cleveland and Toledo showed that the chlorine decreased gradually from about 20 parts per million near the harbor of Toledo to about 6.5 parts in the vicinity of Cleveland. The results of these analyses are shown in the accompanying sketch. The influence of this salt water in the lake was easily appreciated when it was found that at times the water of the Portage River was as salt as sea-water, while the water of the Maumee River and the Sandusky River often contained very large amounts of chlorine. Studies of the situation showed that the increase of chlorine at Cleveland began about the time when the Ohio gas wells were first developed.

The writer's report takes up at some length certain factors which affect the self-purification of lakes, namely, dilution, the natural death of pathogenic organisms in water, sedimentation, and such minor influence as sunlight, aeration, etc. Calculations of the effect of dilution showed that if the sewage of the city were uniformly distributed along the water front the number of bacteria in the water at different distances from the shore should decrease as follows:

Distance from shore. miles.	Bacteria. per cc.
.0-0.5	85,000
.5-1	33,000
1 -1.5	13,000
1.5-2	5,800
2 -2.5	2,500
2.5-3	1,100
3 -3.5	500
3.5-4	230

These figures show that the effect of dilution at a distance of 4 miles from the shore is very great, although it leaves in the water a considerable number of bacteria of sewage origin. It is not from the uniform dispersion of sewage through the waters of the lake that the greatest danger from pollution is to be feared. It is rather from the more direct flow of the water of the Cuyahoga River towards the intake of the water works. This dircet flow is most likely to occur at times when the wind is blowing from the southeast and when there has been a drop in the lake level so as to increase the slope from the river mouth towards the intake. From the best available data it was estimated that a southeast wind movement of at least 200 miles a day is necessary to cause a well-marked current from the river mouth to the new crib. During 1904 there were 41 days when this wind movement exceeded 200 miles, eight days when it exceeded 300 miles, and three days when it exceeded 500 miles. These data taken in connection with the effects of dispersion indicate that the danger of pollution of the water at the new crib is very much less than at the old crib, but yet it is not altogether lacking.

The water of Lake Erie taken from the old crib was not only dangerous from a sanitary standpoint, but at times objectionably turbid and occasionally affected with oily odors. During 1904 the water was noticeably turbid, for 53 per cent. of the year and objectionably turbid for 33 per cent. of the year. The water taken from the new crib, on the other hand, has been much better. Its sanitary quality has been reasonably satisfactory, as shown by the typhoid fever records above mentioned, while it has been noticeably turbid for only 39 per cent. of the year, and objectionably turbid for only 13 per cent. The following figures show the average analysis of water from Feb. 17 to Oct. 1, 1904:

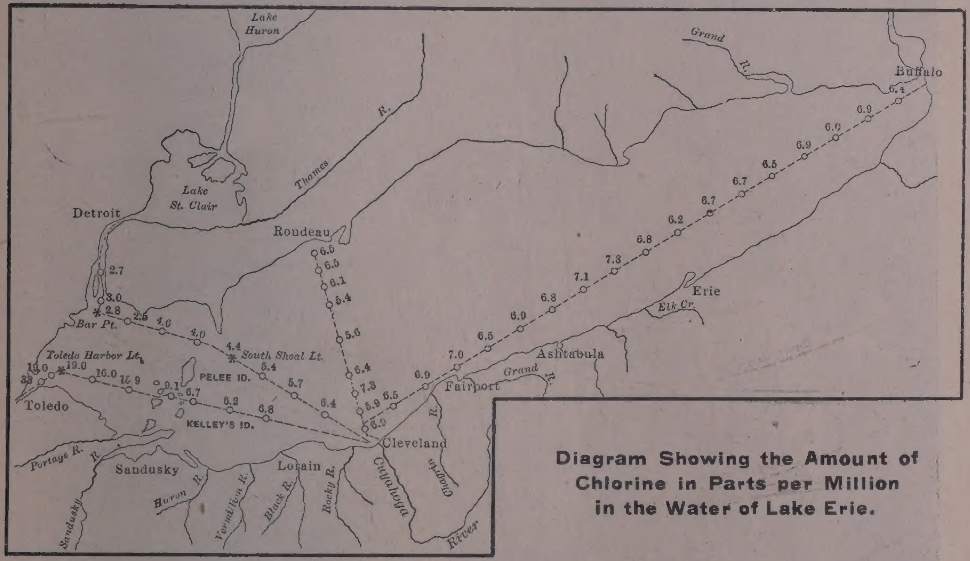


Diagram Showing the Amount of Chlorine in Parts per Million in the Water of Lake Erie.

Physical Examination:—turbidity, 18.; color, 13; odor, 1.3; fishy, 0.05.

Chemical Analysis, parts per million:—Nitrogen as albuminoid ammonia, 0.103; nitrogen as free ammonia, 0.002; nitrogen as nitrites, 0.004; nitrogen as nitrates, 0.06; total solids, 158.0; loss on ignition, 23.0; fixed solids, 135.0; chlorine, 8.2; hardness, total, 106.0; alkalinity, 88.0; incrustants, 18.0; iron, 0.28.

Bacteriological Examination:—Number per cc., 332; test for B. coli, 0.1 cc., 4 per cent. of samples gave positive test:— 1.0 cc., 14 per cent. positive; 10.0 cc., 44 per cent. positive.

Microscopical Examination:—Microscopic organisms per cc., 117; amorphous matter, 287.

The numbers of bacteria found in the water at the new crib have been much lower and have run much more uniformly than at the old crib, while the fluctuations have not been of such a character as to point to a serious pollution of the water by the sewage of the city. The occasional increases in the number of bacteria have been more closely related to the stirring up of mud at the bottom of the lake than to sewage carried directly from the city out into the lake. There have been times, however, when the bacteria appeared to be influenced by contamination of sewage. Thus, with southeasterly winds there have been occasions when the number of bacteria increased and when at the same time the chemical analysis of the water was unsatisfactory, while positive tests were obtained for B. coli.

The chemical and biological surveys of the lake water near Cleveland indicated that east of the city the influence of the Cuyahoga River was felt to a considerable distance from the shore, but that west of the city its influence was very small. At the point where the new crib is located the influence is generally nil, but occasionally noticeable. From the data at hand it seems fair to assume that after the intercepting sewers have been completed the lake water at the new intake will be rarely, and only in a very slight degree, influenced by the pollution of the city. The analyses showed that at times when the wind was off-shore the lake water was polluted for a much greater distance than at times when the wind was blowing in-shore, a fact which would naturally be expected. The analyses indicated further that there are no important eddy currents which tend to carry the sewage of the city westward.

They show also that any effect of the Black River or the sewage of the city of Lorain on the water supply of Cleveland would be so slight as to be practically negligible. Practically the only danger to the water supply of Cleveland is the sewage of Cleveland itself.

General Results.—The general results of the investigations are summarized in the report as follows:

"1. The water of Lake Erie at the new crib at Cleveland, which was used until April, 1904, often showed by analysis strong evidences of pollution with fecal matter, especially at times when the Cuyahoga River was in flood, and when a southeast wind was blowing. It was a dangerous source of supply and it should never be used again unless filtered.

"2. The water of Lake Erie at the new crib is almost unpolluted by the sewage of the city and may be considered at the present time as reasonably safe from the sanitary standpoint.

"3. Occasionally, under certain unfavorable conditions, minute traces of pollution have been detected by analysis in the water at the new crib and under extreme meteorological conditions, such as may occur at infrequent intervals, it is possible that a slight and transitory infection of the new supply may occur. The danger of this, however, is extremely small and need not be seriously considered at the present time. There is reason to believe that some of the unsatisfactory analyses of water from the new crib obtained during the summer of 1904 were due to the dumping of polluted mud, dredged from the river and harbor, into the lake at a point less than two miles from the intake. After it was stopped in the fall the number of unsatisfactory analyses very materially decreased. The practice of dumping this material into the lake so near the intake is a filthy and dangerous one and should be prohibited. The practice of dumping night soil into the lake should be absolutely prevented is possible.

"4. As the use of the water from the old intake was gradually abandoned and replaced by that of the new supply the amount of typhoid fever in the city decreased by degrees which corresponded to increasing proportionate amounts of water pumped at the Kirtland St. Pumping Station and since the water from the new crib has been exclusively used the typhoid fever death-rate in the city has been quite low. During the year ending June 30, 1905, this rate was only 16.8 per 100,000, but it should be observed that the meteorological conditions tending to promote pollution of the water have been recently more favorable than during previous years. It is possible that more serious conditions may increase this rate very slightly. On the other hand, as the scattering foci of infection in the region around Cleveland become less numerous, the rate may drop still lower.

"5. The completion of the intercepting sewer system, by which the sewage of the city will cease to be discharged into the Cuyahoga River and into the lake along the water front and be carried to a point 9 miles east of the city, will materially improve the sanitary quality of the lake water at both intakes, but will not absolutely prevent the pollution of the water at the new crib at all times and under all conditions.

"6. The use of the temporary outfall at Marquette St. will not materially change existing conditions as to the danger of pollution of the water at the new crib. It ought not, however, to increase this danger and there may be reasons why the use of a temporary outfall is desirable.

"7. After the completion of the intercepting sewer system, the danger of pollution of the water at the new crib will gradually increase as the city grows, until eventually the quality of the water may be affected by it to an appreciable extent. Should the sewage be purified before it is discharged into the lake, this would, of course, modify the situation; but to purify the sewage of the city to such an extent as to remove the danger of infection to the lake water would be more difficult and much more costly than to filter the water. It is not likely that such a purification of the sewage will ever be undertaken.

"8. The lake water at Cleveland is not appreciably polluted by other than local purposes, although there are faint indications of the influence of the sewage of Lorain and the Black River on the lake water a few miles west of the city. There is no general pollution of the Lake Erie water worthy of being noticed at present or likely to be important in the immediate future. Cleveland alone is responsible for the pollution of her water supply.

"9. The water of Lake Erie at Cleveland is at times objectionably turbid, not only at the old crib, but at the new crib and even for several miles further into the lake. This turbidity is due chiefly to clay and silt stirred up from the lake bottom by strong winds, but to some extent it is due to the suspended matter carried into the lake by the Cuyahoga River and other streams.

It gives to the water in the city a cloudy appearance, and, at times, causes some complaint.

"10. The water from the new intake does not at present need filtration from the sanitary standpoint, but before many years, when the lake water has become more polluted, filtration will be imperatively necessary in order to protect the health of the city. Furthermore, the standard of quality of public water supplies in American cities is rapidly rising and consumers are more and more demanding water which, besides being safe, is clear, colorless and attractive. When these facts are taken into consideration filtration of the lake water in the not far distant future seems certain, and I am clearly of the opinion that no permanent improvements in the system should be made, therefore, which are not in line with the ultimate filtration of all the water taken from the lake. To postpone a general filtration of the water a few years, however, is not likely to militate against the health of the city.

"11. The water of Lake Erie at Cleveland is an easy one to purify either by the method of slow sand filtration or by mechanical filtration. It is naturally devoid of color and its turbidity is seldom excessive. Filtration of this water would render it eminently satisfactory for all purposes and, except that it is rather hard, it would be second in quality to none of the larger supplies of the country. Even its hardness might be somewhat reduced by chemical treatment before filtration. Inasmuch as either system of filtration is applicable, the selection of the one to be used will be governed by questions of engineering and of cost rather than by comparisons of efficiency.

"12. If it should become necessary, as now seems probable, to provide a larger supply of water for the city prior to the introduction of a general system of filtration, there are many reasons why it should seem expedient to put back into service the pumping station at Division St. On account of pollution, however, this could not be done unless the water from the old intake were filtered or unless the tunnel were extended further out into the lake. It is perfectly feasible to filter the water derived from the old crib and make it safe and wholesome. The water thus filtered would be better than could be obtained by extending the tunnel to any reasonable distance and the project would have the advantage of being in line with future developments of the supply. Nevertheless by extending the tunnel water may be obtained for a number of years reasonably safe for use and as good as, if not better than, that now derived from the new crib. The ultimate filtration of the water from the extended tunnel might be slightly cheaper than the purification of the water at the old intake, where the turbidity is somewhat greater and where the amount of pollution from the river is larger, but the difference would not be an important factor.

"13. If the West Side tunnel were extended, the best location of the intake, from the standpoint of the quality of the water, appears to be a point about three miles northwest of the old crib, three miles from the shore, four and a half miles from the mouth of the Cuyahoga River and an equal distance from the mouth of the Rocky River. Analyses have shown that at this point the water is even less liable to pollution from the city's sewage than at the new crib while the danger of pollution from the Rocky River and from Lorain during the next decade is too slight to be reckoned with.

"14. The relative merits of these two projects for obtaining an additional supply of water from the West Side Pumping Station can be properly considered only after a detailed study of both of them from the standpoints of engineering and cost—matters which lie outside of my instructions and which I have not therefore considered. For sanitary reasons, however, I see no objection to the adoption of either project."

Progress on the Manhattan Work of the Pennsylvania, New York & Long Island R. R.

The East River tunnels of the Pennsylvania, New York & Long Island R. R., described in The Engineering Record of July 14, 21 and 28, will be connected with the great terminal station of the Pennsylvania system by four tracks carried from the East River shafts at First Ave., under 32nd and 33rd Sts., to Seventh Ave., distances of about 5,300 ft. and 5,200 ft., respectively. The tracks will have a down grade of 0.4 per cent. from Seventh to Fifth Ave., and 1.5 per cent. from Fifth Ave. eastward towards the river and will run most of the way through double-track concrete-lined tunnels. The base of rail will be at a maximum depth of about 87 ft. below mean high-water level. The work west of First Ave. is being prosecuted from six headings reached by four shafts, and although only a very small and costly surface space was available for the contractor's use at two of the shafts, operations are conducted rapidly and without confusion. This is largely due to the development of two complete surface plants, the thorough systematization of operations and organization, the use of electricity and compressed air for all power purposes, and the installation of appliances for handling all excavated material without hand labor.

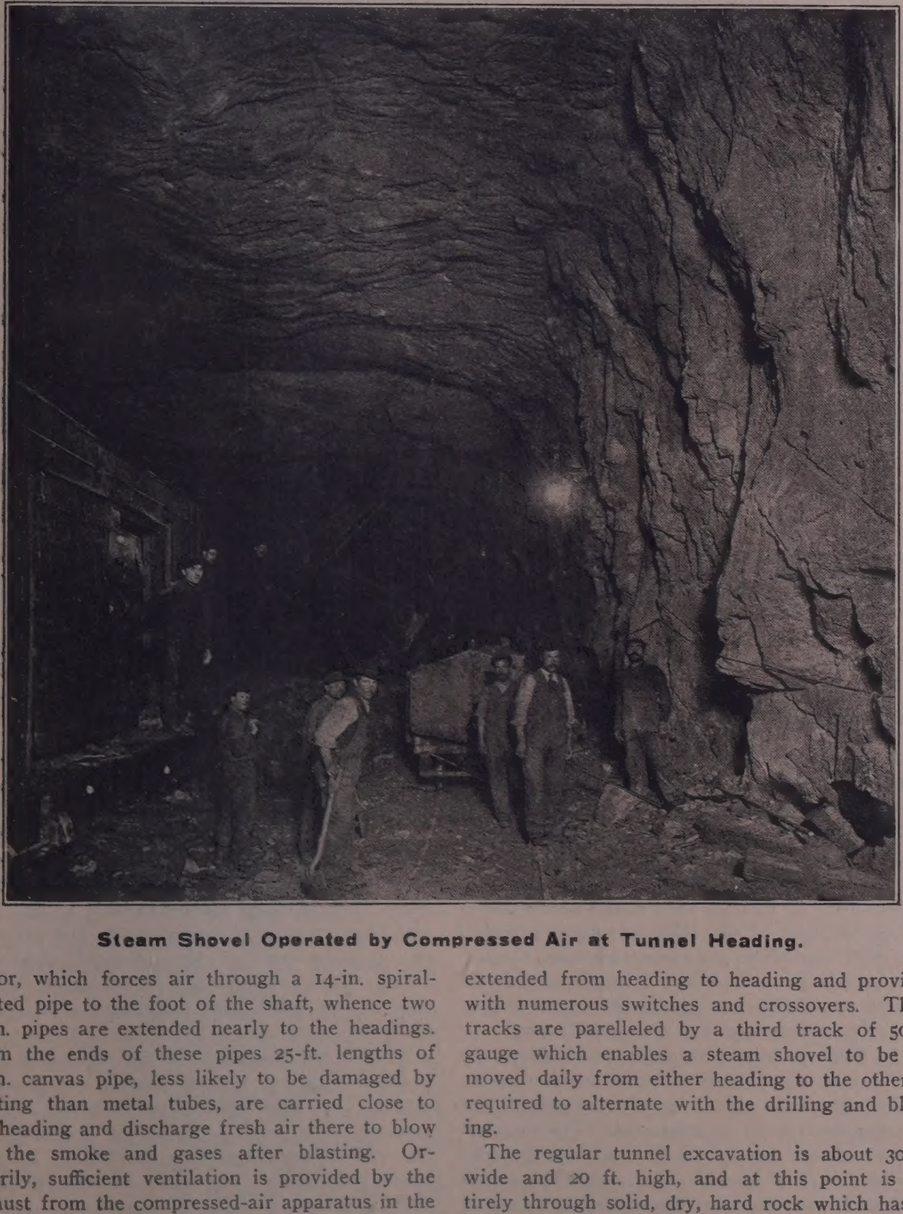
Skips at Foot of 33rd St. Shaft.

The four working shafts are located in pairs, at First Ave., and between Fourth Ave. and Madison Ave., each pair being entirely independent of the other and equipped with a complete power plant. A dock for receiving, delivering and storing materials, a large storage yard and the principal repair and construction shops serve all portions of the tunnels reached through any of the shafts. The railroad company provided an area of about 25,000 sq. ft. for the contractor's purposes around the top of the river shafts and provided two city lots on the north side of East 33rd St. at the site of the 33rd St. intermediate shaft and one city lot on the north side of East 32nd St., at the site of the 32nd St. intermediate shaft. These lots were occupied by stables, which have been demolished and replaced by structures covering the tops of the shafts and providing space for the installation of the power plant and hoisting apparatus. The contractor secured a four-story residence on the south side of 33rd St., directly in the rear of the 32nd St. shaft and connecting with that lot. The basement of this building is utilized for storerooms and the paymaster's office, and provides direct communication for workmen passing from one shaft to the other. The upper stories contain the contractor's general offices and drafting rooms.

The 35 x 100-ft. surface area incloses the 20 x 30-ft. 33rd St. shaft and is entirely occupied by the head-works for the latter, by the unloading platform and by the power building 35 ft. square, which has concrete machinery foundations and steel floorbeams. In it is located all the plant supplying power to this shaft and the adjacent 32nd St. shaft. On the first floor there are two Laidlaw-Dunn-Gordon two-stage 480-h.-p. air compressors, each direct-connected to a Fort Wayne electric motor. Each compressor has a capacity of 2,870 cu. ft. of free air per minute and at 100 r.p.m. maintains a pressure of 100 lb. Each compressor is equipped with horizontal overhead intercoolers, and its discharge is controlled by a governor operated by the fluctuations in air pressure within the receiver. The air for both compressors is drawn through a vertical flue 18 in. in diameter which terminates in a screened intake above the roof of the power house. Two 12-in. branches are taken from it to the compressors and are controlled by throttle valves actuated by the governors of the compressors. The 6-in. delivery pipes from the compressors run to a large vertical receiver, provided with a gauge and a drain pipe. The 8-in. air main is taken from the top, brought down to the floor level and thence carried underground to the tops of the 33rd St. and 32nd St. shafts, where it is connected to 6-in. vertical mains running into the tunnels.

Water for the cylinder jackets and intercoolers is circulated by an electrically driven Worthington centrifugal pump, which delivers the warm water to the top of a Wheeler rectangular steel cooling tower about 10 ft. wide and 40 ft. high, projecting above the power house roof. A metered connection to a city main furnishes water to supply losses from evaporation or to operate the plant without cooling if necessary. The power house contains a switchboard for the compressor service and another which controls the wiring for all purposes in the 32nd St. and 33rd St. shafts. Current is purchased from the New York Edison Co., and is used chiefly for operating the compressors for driving motors above ground, for firing blasts, for lighting and for operating locomotives in the tunnels.

At the heading of the 33rd St. shaft there is a chamber with an A.B.C. fan driven by a 15-h.-p. motor, which forces air through a 14-in. spiral-riveted pipe to the foot of the shaft, whence two 12-in. pipes are extended nearly to the headings. From the ends of these pipes 25-ft. lengths of 16-in. canvas pipe, less likely to be damaged by blasting than metal tubes, are carried close to the heading and discharge fresh air there to blow out the smoke and gases after blasting. Ordinarily, sufficient ventilation is provided by the exhaust from the compressed-air apparatus in the tunnel, and the fan system is operated only after blasting or when humidity or other weather conditions make it especially necessary. A valve at the foot of the down-take pipe enables the whole volume of air or any portion of it to be directed to either heading as required.



Steam Shovel Operated by Compressed Air at Tunnel Heading.

The second story of the power house is occupied by a shop and storeroom and has an annex communicating with the loading platform, which contains dressing rooms and lockers for the men.

The 33rd St. shaft is sunk through solid rock to a depth of 96 ft., measured to the bottom of the 10-ft. pump, and has no lining or timbering, except what is required for two sets of hoisting guides and for the stairway. All electric light and power wires are carried down the shaft in three 2-in. loricated pipes, besides which there are the 6-in. air pipe, the 4-in. pump discharge pipe and a ¾-in. pipe for supplying water under pressure.

As it was necessary to locate the 33rd St. shaft above described on private property at one side of the tunnel alignment, its foot had to be connected with the tunnel by a transverse tunnel, 20 ft. wide and 50 ft. long. This is extended about 20 ft. beyond the foot of the shaft on the opposite side to provide room for a Cameron sump pump with a 4-in. discharge pipe and a single-drum Lambert hoisting engine, the latter to help deliver cars to the shaft hoist. Two 3-ft. tracks with double crossovers run from the foot of the shaft to the main tunnel, where they connect with two main lines of the same gauge, extended from heading to heading and provided with numerous switches and crossovers. These tracks are parelleled by a third track of 50-in. gauge which enables a steam shovel to be removed daily from either heading to the other as required to alternate with the drilling and blasting.

The regular tunnel excavation is about 30 ft. wide and 20 ft. high, and at this point is entirely through solid, dry, hard rock which has so far required no timbering. The tunnel is driven in both directions from the shaft with center top headings. These are blasted out on both sides to the full width. The rock below is taken out in a single bench, although it was first intended to take it out in two benches, and this method may hereafter be adopted if conditions warrant it. In this tunnel there are installed twenty Ingersoll-Rand auxiliary valve drills, four of which are usually operated on two columns in each center top heading, the remainder being operated on columns or tripods as is most convenient.

The blasting is done with a large number of holes charged with small amounts of Forcite powder. Great care is taken to avoid heavy blasting and has resulted in very little vibration or shock in the street. The tunnel has been driven under the subway line of the Interborough Rapid Transit Co. with a clearance of about 35 ft. without causing any injury to the latter structure or even cracking its enamelled tiling.

All blasts are fired with a 120-volt current carried to a point near the heading, where a switch is established with a red light continually burning and protected by a timber shield. When the drill holes are loaded, the miners leaving the heading connect successive breaks in the circuits, and when all are ready the current is turned on at the red light switch and the charges fired. Returning, they open the switch and break the circuit at the successive points in reverse order.

The drills have 1-in. flexible hose connections to a 10-in. pipe manifold on the end of the 4-in. air pipe, which is also provided at intervals of 100 ft. with 3-in. connections for a Marion steam shovel. The shovel boiler is used for an air receiver and is provided with a coke reheater. This shovel is run close to the bench and loads all of the muck and rock into special 2-yd. steel skips, delivered there on flat cars drawn by mine locomotives furnished by the General Electric Co.

On account of the difficulty of maintaining the trolley wires close to the heading, where they would be injured by blasts, the locomotives are only run to a point about 50 ft. back of the bench where they deliver the cars in trains of four or six to a storage siding. From this siding the cars are taken one by one to the steam shovel as required.

A Lidgerwood single-drum hoisting engine mounted on a car and operated by compressed air is situated in the rear of the shovel and operates a steel wire cable led through a snatch block attached to the shovel. The free end of this cable is connected to the empty car and pulls it up to a point alongside the shovel, where it is quickly filled. When the car is filled it is started down-grade by a push from the shovel boom and descends by gravity to the end of the trolley line, whence trains of four cars are hauled back to the shaft by the electric locomotive. A second locomotive draws the cars from the other heading to the transverse tunnel leading to the shaft. Two cars of each train are taken from this point to the foot of the shaft by their locomotives and the other two are hauled to it by the hoisting engine previously mentioned in connection with the extension of the transverse tunnel.

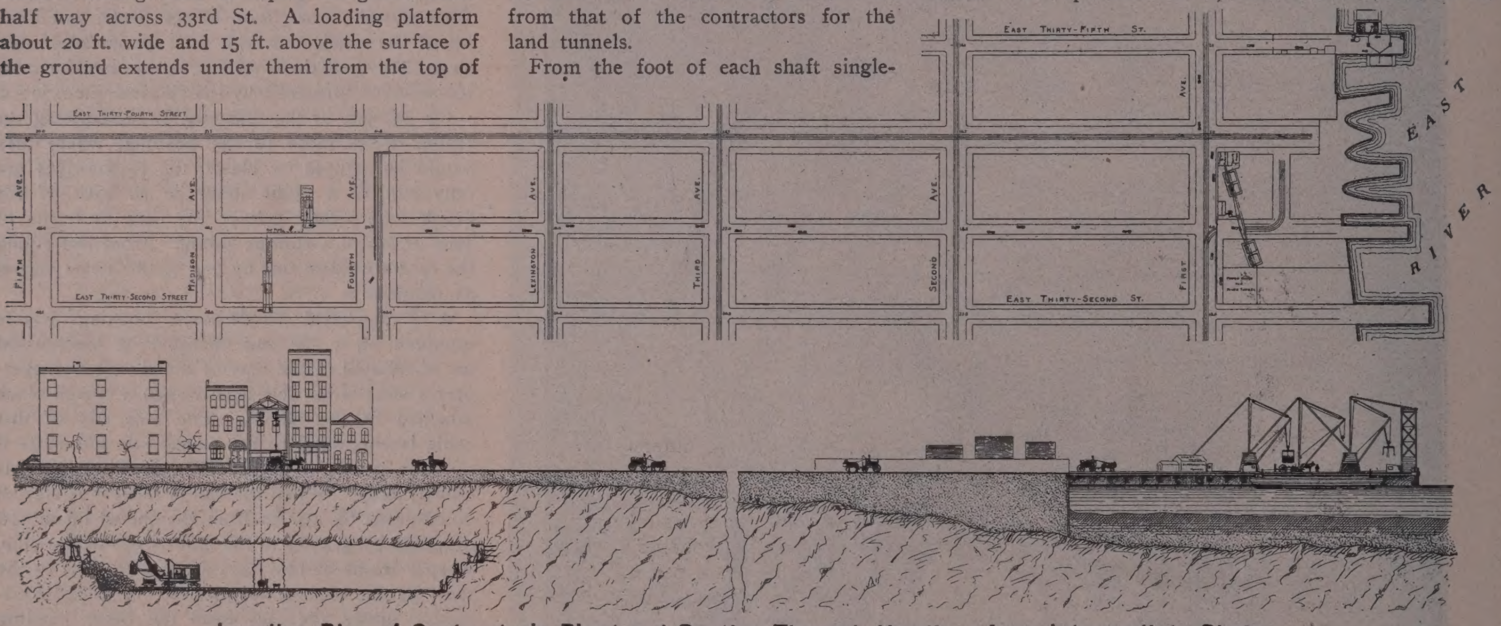
The electric wiring in the tunnel is on the three-wire system, and in order to operate the mine locomotives directly from it, the latter are equipped with special double overhead four-wheel trolleys making contact with both outside wires and towed by a flexible connection to the locomotive. The tunnel is illuminated by incandescent lights, with arc lamps at intervals.

From the transverse tunnel to the west heading, the grade of the tunnel provides drainage without pumping, but from the transverse tunnel to the east heading, the grade is against the drainage and the water is cared for by a movable Cameron pump installed in a sump near the heading and delivering to the main sump at the foot of the shaft.

A Browning locomotive crane is used in the tunnel to handle timber or other materials as required. Like the steam shovel and the pumps it is operated by compressed air. The tunnel is wide enough to afford plenty of room for the main tracks and switches and for benches and tools for making minor repairs to the drills.

The rectangular steel skips in which the muck is handled are of special construction, made in halves pivoted together on the upper edge in the center longitudinal line, as illustrated in The Engineering Record of June 19. Locks are provided to hold them together, but have been found unnecessary. They are handled by horizontal lifting beams with short chains hooked into a ring at each end of the skip just over the pivots. When loaded, the weight of the material keeps the two halves of the skip in contact and holds it closed while being hoisted, and it is easily dumped by revolving the two halves in opposite directions around the pivots. The bottoms of the skips are slightly inclined upwards in both directions from the longitudinal axes and the wooden flat cars on which they are carried have concave bolsters cut to fit them and maintain the skips securely in position.

The flat cars deliver the skips to the bottom of the shaft whence they are lifted about 120 ft., to an elevation above the loading platform by electrically operated hoists in the telpher cars installed by the Dodge Coal Storage Co., of Philadelphia. As there are two sets of hoists in simultaneous operation in the shaft, each of them is provided with vertical wooden guides, and there are two separate connecting telpher tracks reaching from the top of the guides about half way across 33rd St. A loading platform about 20 ft. wide and 15 ft. above the surface of the ground extends under them from the top of the shaft to and across the 33rd St. sidewalk, affording sufficient space for storing a number of full or empty skips. The two independent telpher track rails are carried over it at a clear height of about 15 ft. and cantilever far enough into the street to overhang wagons driven alongside the curb.



Location Plan of Contractor's Plant and Section Through Headings from Intermediate Shafts.

With this apparatus, the loaded skips weighing 4 or 5 tons each, are hoisted from the bottom of the shaft, transferred to the end of the cantilever and lowered to wagons in about two minutes. The wagons bring back the empty skips, which are unloaded from them by the telphers and temporarily stored on the loading platform. After the telpher has delivered a loaded skip to the wagon it picks up an empty skip and carries it back to the foot of the shaft on its return trip. If no wagon is waiting when a loaded skip is hoisted from the shaft, it is temporarily stored on the platform so that no congestion is caused by waiting for either full or loaded skips.

Three telephones are located on the loading platform. One of them communicates with the bottom of the shaft and is supplemented by electric signal bells to govern the telpher's operator. Another communicates with the 32nd St. shaft and is especially useful to prevent delays in the wagon service. The third communicates with the contractor's office and with the city telephone system.

All of the drills used in the tunnel at the foot of this shaft are sharpened in two forges at the top of the shaft. Other repair work and construction is done in the main shops at the river shafts. No bulky material is stored at the shaft, but considerable timber and other property is stored alongside the 33rd St. curb one block farther east.

The 32nd St. shaft and tunnels correspond substantially with those already described, except that the shaft house only provides for the telpher system and for lockers and dressing room, all power being supplied from the plant on 33rd St. The 32nd St. shaft passes through a greater depth of earth and is timbered. The 32nd St. tunnel has an equipment like that already described, but as it passes through a different class of rock it requires timbering in some places.

The two East River shafts are located at First Ave., on both sides of 33rd St. Each of them has a very large rectangular steel and concrete lining, as described in The Engineering Record of July 14, and is divided into four equal parts by a concrete center transverse partition of full height and by a center longitudinal concrete wall in the lower part of the shaft, which separates the work of the contractors for the river tunnels from that of the contractors for the land tunnels.

From the foot of each shaft single-track tunnels are driven to meet the double-track tunnels already described one tunnel being started on each side of the transverse wall in each shaft. The tunnel work conducted from these shafts corresponds in method and plant with that already described, except that the auxiliary hoisting engines used to pull the cars to the steam shovel and to the foot of the shaft are dispensed with and mules stabled in the tunnel are used instead. The tunnels are also driven through rock which requires timbering, and, being of small dimensions, the top headings are driven full width.

The muck is hoisted through the shafts in the special steel skips handled by a telpher system of the same type as that already described, but differing from it in arrangement. The two telpher tracks are nearly 300 ft. long and are substantially parallel to each other, extending across both shafts and between them, so that a car on either track can serve either division of either shaft. The rails, about 50 ft. above the surface of the ground, are carried by wooden trusses with spans of 25 to 60 ft. Owing to the limited width of the portions of the shaft allotted to this contractor, there is not sufficient clearance for the two telpher cars to pass each other over the shafts, and they are arranged with the rails converging at these points so that either car may be operated there alone. In the space between the shafts the rails diverge so that the cars can pass. As only one car can be operated at once in each division of the shaft, guides are not provided for the skips.

The skips are hoisted to the car and are then transferred by it to a point nearly midway between the shafts, where they are deposited as previously described on wagons, which in this case are driven up a long incline and receive their loads on a working platform carried across 33rd St. at a sufficient height to allow the street traffic to be maintained uninterruptedly below it. This arrangement facilitates the handling of the muck, avoids street obstruction and provides a considerably enlarged area for the contractor's use.

In the contractor's yard adjacent to the river shafts is located a power plant for the tunnels driven from this point. The two-story power house has steel floorbeams and corrugated iron sheathing and contains on the first floor a Laidlaw-Dunn-Gordon compressor like those at the 33rd St. plant. There are also two smaller compressors of the same make, with capacities of 1,250 and 650 cu. ft. of free air per minute. The latter is operated by a single 100-h.-p. motor. As it was difficult to secure a 200-h.-p. motor promptly for the larger compressor two 100-h.-p. motors were provided for it, both of them belted to the same driving wheels, one belt being inside the other, an arrangement which works satisfactory and expedited the installation.

The air compressors are governed in the same manner as those at 33rd St. and a cooling tower like that previously described is also installed here. The working space available at this shaft was larger than at the other shafts and permitted the location here of the principal shops and storage yard required for the contractor's purposes. The smith shop adjacent to the power house has seven forges with compressed air blast, and in it are made all of the drills and small forgings required on the work. An ingenious machine has been constructed from an air drill mounted in a vertical frame for shanking drill bars which are afterwards finished in an Ajax upsetting machine, both driven by compressed air. Bars are kept in stock in considerable quantity for drills and other tools.

The elevated platform under the telpher tracks has an area of about 3,000 sq. ft. and on it are corrugated iron sheds for the machine shop and carpenter shop. The former has a circular saw for framing tunnel timber and the latter is supplied with lathe, shaping machine, drill presses, planing machine, bolt cutter, etc., all operated from a line shaft driven by a 10-h.-p. motor, which, like all other motors except those driving the compressors in the 33rd St. power house, are of the General Electric Company's manufacture.

It is contemplated to extend the platform eventually over a larger portion of the yard around the shafts and use it for storage, repairs and other general purposes so as to permit the use of most of the ground space below it for the storage of sand, broken stone and cement for the concrete tunnel lining, which will require about 120,000 cu. yd. of concrete. It is intended to prepare the concrete in Smith mixers driven by electric motors at the foot of the south river shaft. A vertical bin 6 ft. wide and 12 ft. long with reinforced concrete walls has been built against each side of the transverse partition and shaft and extends from the surface of the ground to a point near the tunnel invert, where it terminates in a hopper bottom. These bins are to be used for storing sand and broken stone. They can be filled easily from the surface of the ground and will discharge by gravity directly to the mixing machines, from which the concrete will be distributed along the line by one yard steel side-dump cars. Cement in bags will be delivered down the shaft by spiral chutes.

At the head of the shaft a 10-yard hopper bottom bin is provided for the tamping sand. This is thoroughly dried and is made into cartridges for convenience in filling the drill holes over the charges. Boys with conical tin scoops fill the sand into paper bags about the size of the sticks of powder. The bags are then packed into the original powder boxes and delivered to the miners, who find them very convenient in loading the drill holes, especially when the latter are inclined upward.

The muck from all shafts is drawn by teams to the contractor's pier at the foot of East 35th St., where the skips are unloaded from the wagons and dumped into scows, moored to either side or at the end of the pier, by two stiff-leg derricks with 40-h.-p. Lambert hoisting engines operated by electric motors. A third similar derrick with a 60-h.-p. engine is used for handling timber and other materials and for unloading sand with a one-yard clam-shell bucket. All of the derricks are swung by bull wheels and those used for handling the skips are provided with a special dumping apparatus which enables them to be operated with great ease and rapidity. Two lines are attached to the lower edges of the skips, which, as already mentioned, are pivoted on their upper edges. These lines are secured to a single line parallel with the hoisting line which runs to the foot of the boom and thence past the hoisting engine shed and around a drum, and carries a counterweight sufficient to overhaul it and maintain a moderate tension when the skip is hoisted. In order to dump the skip, this line is held fast by a brake engaging its drum and operated by the engine driver. At the same time the skip is lowered slightly by the hoisting tackle, thus throwing the weight entirely on the dumping line, which causes the upper edges of the skips to revolve downwards between the lower edges, spreading the latter apart and opening the bottom of the skip so as to allow its contents to be discharged. When the brake is released and the hoist line is operated, the skip automatically closes and is seated again on the wagon, which returns it to the tunnel to be refilled.

As much as 800 yd. of rock daily have been excavated from the different tunnels in this contract and are delivered as here described to dump scows provided by the Pennsylvania Railroad Co., which are towed to Greenville, where their contents are used for making an extensive fill. The pier is used to some extent for storage and on it there are located two first-class powder magazines with reinforced concrete walls and arched roof and shelving for 1,000 lb. of powder. They are kept locked and guarded and entrance is permitted only by special order. Hot water coils are provided for thawing the powder in cold weather and are run under the shelves, on which the sticks of powder are arranged in single tiers as unpacked from the boxes. The powder is delivered from the magazine to the shafts and tunnels by employees of the powder company.

Work is carried on continuously with three eight-hour shifts of 100 to 200 men each, and a total monthly progress of as much as 1,000 ft. has been made in the headings now under way. About 6,000 lin. ft. of tunnel excavation, equivalent to about sixty per cent. of the entire excavation required, has been finished.

The work is being erected under the direction of Mr. Alfred Noble, chief engineer of the East River Division of the Pennsylvania, New York & Long Island Railroad Co., and is being executed under his direction by the United Engineering & Contracting Co., Mr. D. L. Hough, president, and Mr. Paul G. Brown, managing engineer.

The Construction of Low-Cost Country Roads.

In the planning of roads to receive State aid, one of the criticisms heard most frequently at first is that the cost of the proposed construction is too great or unnecessarily great. This complaint has been made regarding the work done under the direction of the Maryland Geological Survey, and a very good answer to it has accordingly been prepared by Mr. W. W. Crosby, chief engineer of the highway division of the Survey. At the outset he states that the average cost per mile of the Maryland work has been considerably less than that of similar work in other States, and it is believed by those who have had an opportunity to compare the results in the different localities that the construction is as serviceable and permanent as the more costly roads elsewhere, although perhaps slightly less attention has been paid to finish and the appearance of details, and less grading done.

Could the figures in the different counties of the cost of construction and maintenance of county roads be accurately secured, they would undoubtedly show, Mr. Crosby states, that it is not only good business for the counties to invest their half of the average of $5,300 per mile in improving the more important county roads, according to the methods of modern road building, but that a still greater investment would be warranted. In such individual cases where the figures can be ascertained, this statement is fully borne out. For instance, in Queen Anne's County, the Survey, in response to an application, planned and estimated the cost of improving three miles of road ou[illegible] Centerville. On account of the desire[illegible]ion of some bad grades on hills [illegible]cessity for rebuilding several old rick[illegible]oden bridges, the cost of the work ran up to $7,000 per mile, which figure included a macadam surface for the road. The clerk to the County Commissioners informed us that the county had spent, during the past ten years, an average of $500 per year on this stretch of road, not including the amount spent for repairs to bridges. The cost to the county, under the State Aid Act, of the proposed improvement would have been less than $11,000, interest on which at 4 per cent. would be $440 per annum, a saving over the amount actually expended on this road of at least $60 per annum, neglecting entirely the total saving in repairs to bridges—as the new bridges were planned to be of concrete and would have required no repairs—and neglecting further the advantages of reduced grades and a stone surface in good condition every day in the year as compared with steep grades and an impassable road during certain seasons. A modern macadam road in such a locality should require no material repairs for at least twenty years, and at that time the resurfacing necessary would amount to less than $2,000 per mile.

It has been said that good enough roads should be built for $1,000 per mile. To macadamize a mile of road with stone 12 ft. wide and 6 in. thick after rolling, requires from 1,900 tons of limestone to 2,300 tons of trap rock. This material costs, delivered on the road, from $2,000 to $4,500. It will be seen that the material alone is a large part of the cost per mile, and to meet the criticisms from those who have watched the construction of permanent work in some of the counties, would require the use of at least 50 per cent. more material, thus materially raising the cost. By the use of modern machinery and methods it has been proved that even with the apparently thin layer of macadam used a modern road is fully as permanent and more satisfactory than those built of considerably more material under old methods, and that an actual saving in cost is made. Many of those who estimate that roads should be macadamized for $1,000 per mile have in mind particular instances where, through contributions from those interested, of labor, or men and teams, where no grading, culverts, or bridges were required, and at a period when materials could be secured more cheaply than at present, perhaps the bare cash expenditure was kept approximately to this figure, although it is extremely doubtful if the figures are exact and cover all the items. The records show that the turnpikes of Maryland cost from $7,000 to $10,000 per mile, and even more in some cases.

There has been some discussion lately regarding the advisability of more extensive construction of gravel roads, it being assumed by some that this would make it possible to build more miles of road with the amount of money annually appropriated for the State highway work. There has been little complaint as to the excellence of the roads already built; but it has been contended that greater use of gravel for surfacing would so lessen the cost that a very much greater number of miles could be built, and in this way many localities might be relieved in the cost of caring for their roads. With the number of miles of road in the State, and the amount of money annually appropriated it is impossible to build macadam roads in all localities, and no one believes that such a course would be wise. In the construction of a good road with any surfacing material, there must always be a large amount of grading, drainage (both surface and underground), bridge work, including culverts, guard rails, etc., the cost of which will be a large share of the whole, and will not be affected by the character of surface material.

There are some places in the State where good gravel is obtainable at comparatively small expense, and there is no doubt but that in such places gravel roads could be built for less money than macadam roads; but there are many other cases where it would be quite as expensive to build a gravel road as it would be to build one of macadam. Nor can there be any doubt that a macadam road, once properly built, is the cheapest road in the end, on account of the small expense for annual maintenance. Owing to the varying conditions in different parts of the State, a careful study must be made of each individual case before it can be decided what kind of a road should be built, and consideration must be given to the amount and character of traffic to which the road is subjected. In some cases elsewhere gravel roads have been built which have turned out very satisfactorily. How far this can be carried out in Maryland is a question which can better be decided by a few years' experience; but Mr. Crosby favors the use of gravel or other less expensive road material whenever the local conditions are such as to justify it in so doing. In determining this, however, it is necessary to keep in view the fact that the final and continued cost of the system will be measured by the cost of maintenance, and also the fact that the public highways are sure to be used by a much larger number of people in the future than in the past. It is entirely probable that good gravel can be obtained in some localities which have heretofore been thought to possess none that could be used for road building.

Roads built of screened gravel, the stone of which corresponds in size to the stone used in macadam construction, have given good satisfaction, but the wear is considerably more marked on the gravel roads. Many prefer gravel roads to macadam to drive over. They keep in good condition the greater part of the year, but in spring and fall, if there is much rain and cloudy weather, the gravel road dries out slowly and ruts form easily. This occasions more or less adverse criticism. The screened gravel roads are easily maintained but wear rapidly, and, as the cost of resurfacing is nearly as great as the cost of resurfacing a macadam road, it does not seem to be economy to advise their construction except in localities of light travel where stony gravel is abundant and broken stone obtainable only at great expense.

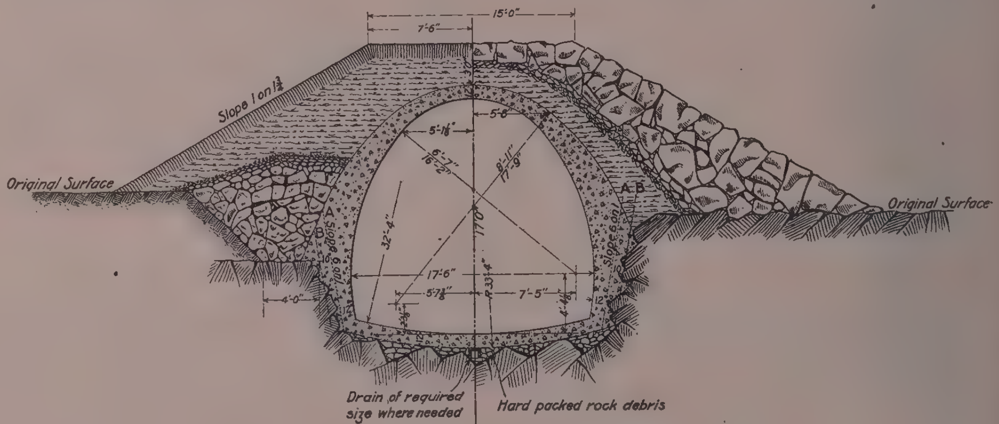
The gravel beds of the State vary exceedingly in their fitness for road construction. In most of them, where the pebbles are mainly of quartz or other flinty rock, and have been much rounded and smoothed by water action, the material is certain to afford a shifting foundation for ordinary wheels, unless a large amount of binding material is used with the pebbles, in which case the road becomes very muddy in wet weather. In cases where the pebbly matter has been derived from rocks of varied constitution, especially where, as is often the case, the bits have undergone a certain amount of decay, the mass may, when well rolled either by steam rollers or even by broad-tired wheels, become consolidated so as to afford a fairly good road.

Nearly all gravel banks now in use contain more or less stone from the size of an egg upward, with quite a large percentage exceeding 2½ inches in diameter. No stones larger than 2½ inches should be used within 4 inches of the surface in the construction of a road. The general tendency is for these large stones to work to the surface and to make a very rough, uneven road after it has been in use for a short time. Fine gravel will not make a good road if the travel is at all heavy. The small stones quickly crush up, and the surface of the road becomes uneven and muddy. It is very doubtful if in a term of years a gravel road will not cost as much as a macadam road, and it can never be as enduring. The wearing surface receives the shock of all traffic, and the materials for its construction must be carefully selected.

The fundamental difficulty with all roads made of ordinary gravel is to be found in the fact that the fragments of the material cannot be made to bind together, however well they may be compressed by the use of the roller; the result is that the first condition of the roadway surface, which should shed water like a roof, is not obtained. The rain penetrates vertically downward through the mass, breaking up what little adhesion may have been brought about, so that when a heavy team passes over it the load is not upheld. The wheels do not penetrate to any great depth in the roadway, but they form ruts, by loss of material which is ground up by that passage. Moreover, this rut becomes a place in which the water is held, and its penetration downward and the consequent softening of the roadway insures its destruction.

There are some of the roads of the State that might be surfaced with gravel, and its use would satisfy the demands of the traffic. It is, however, an unfortunate fact that good road-building gravel is, as compared with stone, a scarce article in Maryland. It is by no means as well distributed as is stone. Saving of cost in its use is generally prohibited when the supply has to be carted more than 1½ miles, or when screening is necessary to remove a surplus of fine sand or dirt or of coarse stone.

No just comparison can be made between gravel roads and macadam, as at no time is a gravel road in a condition to give first-class results. Suppose a two-horse load of gravel delivered on the road costs $1 to $1.25 a load of about 1¼ cu. yd. A road made about 6 in. in depth at this price would cost from 20 to 25 cents a square yard. More or less new gravel has to be put on each year, and it is safe to say that at the end of each five years an amount equal to the original depth has been used. This makes the total cost about 4 to 5 cents a square yard annually. If a macadam road be built of broken stone costing $2.15 per cu. yd. of metal on the road, including rolling, the cost per square yard would be about 47 cents. A road built in such a manner would easily withstand the traffic common to localities removed from the business centers for twenty years, with slight repairs during that time. This would make the annual cost per square yard about 2⅓ cents. By these estimates the macadam road in a term of twenty years will cost from about 1⅔ to 2⅔ cents per square yard less annually than the gravel road.



Cut and Cover Sections of Catskill Aqueduct in Rock.

The same argument could be continued by a comparison between trap rock as the best metalling for macadam roads, or mica schist the poorest. With light traffic in a district abounding in the poorer material it might be shown to be economy to use it. On the other hand, if the traffic was known to be heavy, it would probably cost less in a term of years to use the best of trap rock, although it might have to be shipped a long distance by rail.

The cost of constructing and maintaining a shell road 12 ft. wide and 12 in. thick in the center, reducing to 10 in. at the side, may be based upon the following estimates: Such a road requires about 9 bush. of shells per linear foot, or approximately 48,000 bush. of shells per mile, the cost of which is about 5 cents per bushel for the material and 1 cent per bush. for the hauling, making a total of $2,880. For the maintenance of shell roads in the vicinity of Salisbury, Md., from 2,000 to 3,000 bush. per mile are required each year, which, at the rate of 6 cents per bush., annually cost about $150 a mile for keeping the road in good condition. Distributing the original cost over, say, 40 years would make it $72 per year to add to the $150 per year for repair material, a total of $222 per year.

If, instead of shells for a wearing surface, there should be used material which offers ten or fifteen times as great resistance to wear, repairs would necessarily be much lighter and less frequent. The relative value of shells as compared with the average limestone is as 9 to 1; compared to granite as 11 to 1; compared with trap rock as 16 to 1. Thus, under similar conditions, a stone road would last about twelve times as long as one built of shells.

The cost of shell roads is estimated to be from $2,000 to $3,000 per mile, according to the width and thickness of the shell covering. It would then be a saving if a surface could be constructed of material, for example, which had ten times the wearing qualities of shells, and costing, perhaps, five times as much.

There is scarcely an important center on the Eastern Shore of Maryland not in the immediate neighborhood of a wharf. Thus to all parts of this section of the State there could be sent, by water, broken stone from some of the numerous points at the head of the Bay, where there is abundant material. The estimated cost of broken stone per cubic yard, delivered at the wharf, in places on the Eastern Shore varies from $1 to $2. Shipped by rail, the cost would be greater.

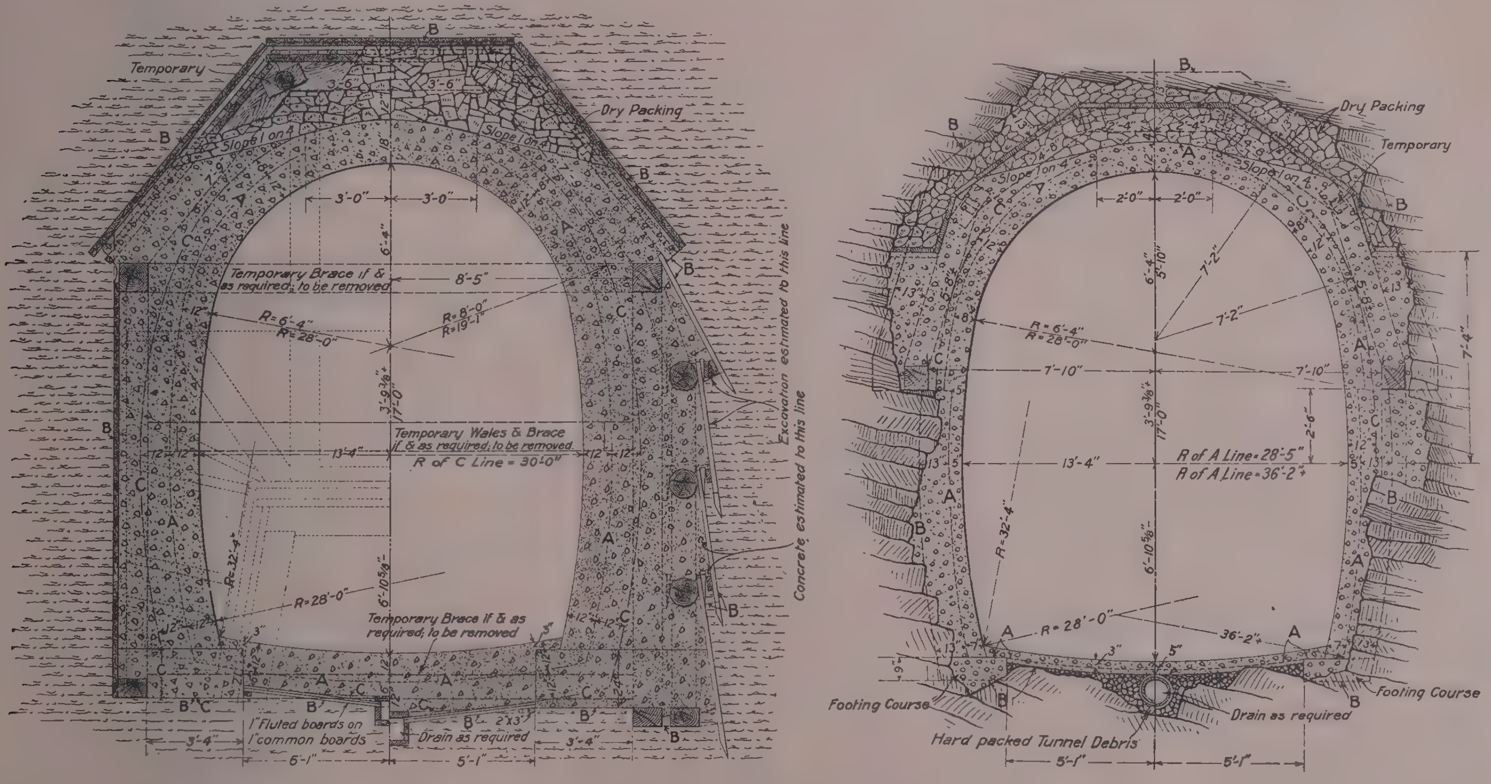
Suppose that instead of shell at $2,000 to $3,000 per mile, stone were used, at $1.50 per ton delivered at the railroad station. Using 2,000 tons to the mile of road would make the cost of the stone for the mile, including hauling at 25 cents per ton, equal $3,750. Allow $1,250 for spreading rolling, profit, etc., and call the total cost of the macadam in place $5,000 per mile. At the end of twenty years such a road would require resurfacing at a cost of not over one-half the first cost = $2,500, so that the total cost for, say, forty years will be $188 per year. This would be an advantage for the macadam over the shell surface of $34 per year. For a longer term, the advantage would be still greater. The indications at present point to a reduction in the prices for crushed stone in the future and increased prices for oyster shells.

The Railway Statistics of the Interstate Commerce Commission for the year ending June 30, 1905, give the total single-track mileage in the country as 218,101.04 miles, owned by 2,167 companies. At the close of the year there were in use 11,618 passenger locomotives, 27,869 freight locomotives, 7,923 switching locomotives, 947 locomotives in miscellaneous service, 40,713 passenger cars, 1,731,409 freight cars and 70,749 cars in company use, as well as a large number of cars owned by private parties. The total number of railway employes on June 30, 1905, was 1,382,196, and the expenditure for wages and salaries during the year was $839,944,680. The par value of the outstanding railway capital was $13,805,258,121, of which about half was stock. The passenger mileage was 23,800,149,436, and the ton-mileage of the freight traffic amounted to a total of 186,463,109,510.

Details of the Catskill Aqueduct, New York.

Through the publication this week of plans and specifications for a portion of the Catskill aqueduct, it is now possible to form some idea of the details of this great conduit. It will begin at Ashokan reservoir in the Catskill Mountains and run to Kensico reservoir near White Plains, and thence to Hill View reservoir in Yonkers, its total length being about 82 miles. The portions comprised in the first contract are in the Peekskill division of the Northern Aqueduct Department, and lie east of the Hudson River in the towns of Cortlandt, Yorktown and Phillipstown. The work includes 41,880 ft. of trench and embankment conduit, three tunnels having lengths of 2,350, 11,430 and 900 ft., and 210 ft. of experimental reinforced concrete pipe at an inverted syphon across a brook. The contract also includes the reconstruction of about 3 miles of roads, and the building of fences, culverts, blow-offs, manholes and many other minor works.

In open trench and on embankments the aqueduct will be constructed of Portland cement concrete and be 17 ft. high by 17½ ft. wide inside. The lining of the tunnels, whether in earth or rock, will be of the same material and be 17 ft. high by 13 ft. 4 in. wide in the clear. The reinforced concrete pipe will be 11 ft. in diameter inside and about 8 in. thick. Foundation embankments will be required under less than half a mile of the aqueduct covered by this contract, but cover embankments will be needed over all parts not in tunnel. In general the cover will be 15 ft. wide on top and 3 ft. deep over the top of the conduit, with side slopes of 1 on 1¾. In deep cuts, the filling may take the form of an embankment over the aqueduct in the center of the excavation, or the contractor may be required to refill some parts of the trenches to the original surface of the ground. The central portions of embankments on which the aqueduct rests are to be built of carefully selected earth containing no stones larger than 3 in. and placed in 3-in. layers, watered and rolled. The layers of earth outside this central portion will be 6 in. thick, watered and rolled, unless the engineer considers them sufficiently compacted by teaming over them. Refills and embankments may be made largely of rock from the excavations, if the engineer permits.



Two Types of Grade Tunnel Sections in Earth and Rock.

The cross-section of the aqueduct along the cut-and-cover portions of the line is shown in an accompanying illustration, referring specifically to work done in rock trench. The hydraulic elements of this section are given in an accompanying table. When the aqueduct rests on earth, the invert is to have a thickness of 16 in., and when an embankment is used for a foundation, reinforcement rods are to be placed in the concrete of the invert. In wet earth the invert is to have a thickness of 16 in., when the ground water surface is 9 ft. or less above the invert; for each additional foot in height of the ground water 1 in. is to be added to the thickness of the invert. In wet earth, the concrete is carried by a platform consisting of one or two courses of plank resting on sills at each side of the cross-section and on a wooden box drain at the center. These planks are grooved or fluted so as to afford small channels by which the ground water is conducted to the drain, and strips of tarred paper are laid over their joints.

The general method of construction to be followed in the cut-and-cover portion of the aqueduct is that the invert of the section will be laid in one operation and the side walls and arch in another. The sections of the invert are to be not over 15 ft. long, with a keyed joint between adjacent sections. The portion of the aqueduct above the invert will be built in sections of a length equal to some multiple of the length of an invert section, but in no case over 75 ft. After a section has been once begun, the concrete work must be carried on continuously and the contract stipulates that an interruption exceeding a quarter of an hour may be deemed sufficient cause for the rejection of the whole section. Temporary manholes are to be left not more than a quarter of a mile apart.

The general character of the grade tunnel sections is shown in the accompanying illustrations and their hydraulic elements in the table. In case very wet ground is encountered or there is any other reason for constructing the masonry in very short sections, the engineer will be given the right to substitute brickwork for concrete.

In rock tunnels, the rock must be removed so that no points project within the line marked A, and no edges or flat rock surfaces may come so close to the A line of the walls or arch as to reduce the effective thickness of the lining below 5 in. outside of the A line or below its neat dimensions at the top of the arch for more than 3 ft. in any consecutive 6 ft. of tunnel. The B line defines the limits to which the contractor will be paid for excavation.

In the standard drawings for earth tunnels care has been taken to place the timbering far enough out to allow for reasonable settlement. To save expensive measurements and computations, the limit of the excavation to be used in the computation of quantities is the B line No timber is to project within the A line, while the C line indicates the standard thickness of the masonry, within which only arch blocks, posts and cross sills may project.

The concrete lining of the tunnel is to be kept as close as possible to the face of the completed excavation. In rock or firm earth the invert need not be laid until after the excavation is finished.

One of the most interesting parts of the work in this first contract is the experimental section 210 ft. long for testing the practicability of reinforced concrete inverted syphons. This section will be 11 ft. in diameter inside, and have an 8-in. arch. It will be carried on a concrete base 15 ft. 9 in. wide. The reinforcement for a part of its length will be rings of 1⅜-in. steel, twisted and welded and placed 3 in. from the outer surface of the concrete. In the other part of the section two rings of 1-in. twisted and welded steel, 3½ in. apart, will be used at each place where transverse reinforcement is used. The single rings are 4⅝ in. apart as a rule, and the double rings 4 15/16 in. The 1-in. twisted longitudinal rods are twelve in number with each kind of rings. The section will be closed by a bulkhead at each end so that it can be subjected to heavy hydraulic pressure.

In making the experimental syphon it is proposed to construct three 30-ft. sections with sand and gravel from some local pit, and four sections with broken stone and screenings.

The gravel and broken stone are to be ⅛ to 1 in. in size and the sand and screenings ⅛ or finer. It is further proposed to try two methods of preparing the concrete. The first is to prepare a very wet mixture in a machine placed above the top of the pipe, from which the sloppy mass can be discharged through chutes directly into the forms, where it will be joggled so as to settle around the steel and against the forms. The second method consists of mixing the concrete to a plastic consistency and tamping it thoroughly in thin layers. Concrete for the invert is to be placed from the interior up to a point where it slopes about 1 on 3, a section being left out of the inside centering for the purpose. The outside form is to be placed as the concrete rises, in order to allow ramming at a low angle where the concrete placed from the outside joins that placed from the inside.

HYDRAULIC ELEMENTS OF THE CATSKILL AQUEDUCT SECTIONS.

Sect.	Depth.	Area.	Wet. Per.	Hyd. Rad.
Trench......	17.0	241.00 sq. ft.	57.4 ft.	4.20
"	16.2*	237.7 "	50.8 "	4.67
"	15.3	230.9 "	47.7 "	4.84
"	14	217.6 "	44.1 "	4.92
"	12	192.6 "	39.4 "	4.88
"	10	163.2 "	35.0 "	4.65
"	8	130.7 "	30.9 "	4.24
"	6	97.1 "	26.8 "	3.61
"	4	62.2 "	22.8 "	2.72
"	2	27.0 "	18.8 "	1.47
Tunnel......	17	198.6 "	52.2 "	3.80
"	16.25*	195.6 "	46.0 "	4.25
"	15.3	188.5 "	42.7 "	4.41
"	14	175.7 "	39.3 "	4.46
"	12	152.4 "	35.0 "	4.35
"	10	126.8 "	31.0 "	4.10
"	8	100.2 "	26.9 "	3.72
"	6	73.8 "	22.9 "	3.22
"	4	47.6 "	18.9 "	2.51
"	2	21.0 "	14.9 "	1.49

Note.—The maximum discharge takes place at the depth marked *. The slope in trench is 0.00021 and in tunnel 0.00037.

The small culverts under the cut-and-cover portions of the aqueduct have been designed in three standard sizes, with clear inside widths of 3, 4 and 5 ft. and heights of 3, 3½ and 4 ft. With a fall of 0.01, these are considered adequate for drainage areas of 65, 160 and 260 acres. In some cases, an opening is made between the aqueduct and culvert and provided with a sluice gate to serve as a blow-off. In other cases, where the culvert is large, two such connections are made, but gate valves located in a manhole outside the aqueduct walls are used instead of sluice valves. In still other cases, blow-off pipes are conducted from such a manhole to the side of the embankment. Where these manholes occur, composition spikes 7½ in. long and 1 in. square are built into the masonry near the top of the shaft; one end projects about 1½ in. and has a knob at the top for a benchmark. The elevation is indicated on a metal tag attached to the spike.

An unusual detail of the tunnel designs is the use of reinforced concrete ladders in the shafts of the tunnels. These are to be both single and triple. The plans for one of the latter type call for four 4x2½-in. posts about 15 in. apart, with L-shaped 4x4-in. rungs about 12 in. apart. The posts are reinforced by a ¼-in. twisted rod in each corner, and a wrapping of expanded metal. These ladders are to be cast in sections and seasoned under cover for at least a month before being attached to the concrete lining of the shafts.

Naturally enough in view of the enormous amount of concrete to be employed on the new water-works, the requirements for this material will arouse much interest. The specifications for Portland cement, which alone is used on this contract, are the same as those of the American Society for Testing Materials, with the following additional clause: "Neat briquettes shall show a minimum increase in strength of 10 per cent. and sand briquettes 20 per cent. from the tests at the end of 7 days to those at 28 days." The cement must be of brands in successful use on large American works for at least five years and come from mills in successful operation for at least two years. The tests will be conducted according to the methods recommended by the Committee on Uniform Tests of Cement of the American Society of Civil Engineers.

Most of the concrete used on this contract will be mixed approximately in the proportions of one volume of cement to eight volumes of sand or screenings and gravel or crushed stone, the sand or screenings and the ballast to be measured separately. The sand, screenings and ballast will be analyzed mechanically from time to time, so that the proportions to obtain concrete of the required density can be ascertained. In measuring sand and screenings allowances will be made for variations in moisture. If it is suitable for the purpose, material direct from the crusher or bank may be used without screening and subsequent mixing, but only with the permission of the engineer. Sand and screenings must not be larger than ¼ in. nor contain more than 3 per cent. of perishable matter, nor enough clay or loam to render it unsuitable, in the opinion of the engineers. Ballast may be either gravel or crushed stone of satisfactory quality from ¼ to 2 in. in size.

Mixing must be done in machines except where small amounts of concrete are required. The specifications permit both wet and medium mixtures. Wet or liquid concrete must be deposited so that it will not flow along the forms, and must be continuously and sufficiently joggled to expel the air. Large stones are to be spaded away from the face, care being taken in doing so to prevent an upward flow which will wash the cement from the concrete at the face. Where a medium wet (plastic) mixture is employed, it will be placed in 6-in. layers, rammed thoroughly and spaded to keep the large stones from the face. In special cases where the concrete must be placed on steep slopes, a dry mixture in 4-in. layers may be used. Stones up to one-man size may be placed in the haunches, with the engineer's permission.

It is expected that the faces of the concrete will be so smooth and dense that no plastering need be done, and any such work must be executed at the contractor's expense. The forms must be watertight and those for the interior surfaces must either be of metal or have a smooth metal covering. The finished surface of the invert must be equivalent to good granolithic work. If it seems necessary for this purpose, a small amount of 1:2 mortar may be placed in the molds with the concrete.

The work is under the general charge of Mr. J. Waldo Smith, chief engineer, whose office and that of the Headquarters Department, with Mr. Alfred D. Flinn, department engineer, is in New York. Mr. Robert Ridgway is the department engineer of the Northern Aqueduct Department in which this section lies, and Mr. A. A. Sproul is the division engineer who will have immediate supervision of it. The offices of Messrs. Ridgway and Sproul are in Poughkeepsie and Peekskill respectively. The plans have been prepared with the assistance of Messrs. John R. Freeman, Frederic P. Stearns and William H. Burr, consulting engineers.

THE ABATEMENT OF SMOKE produced by its locomotives is the purpose of an order which has recently been issued by the Baltimore & Ohio R. R., to its engineers which is intended to secure better management of fires and locomotive operation. It is required that hereafter all fires shall be in good condition at the time the locomotive starts out on a trip, that all lumps of coal be reduced to the size of a man's fist and that the coal be sprinkled freely with water before being placed upon the fire.

The Hoffman Drainage Tunnel.

The Hoffman tunnel, the completion of which has lately attracted so much attention in mining circles, was driven as the principal factor in the drainage of the "Big Vein" workings of The Consolidation Coal Co. in the region about Frostburg, Md., and the company is now making auxiliary channels, driving through the bottom rock of the seam, which will feed into this tunnel from different parts of the field. The workings are in the famous Georges Creek "Big Vein" seam of coal, corresponding geologically to the Pittsburg coal bed. They lie in a basin, the lowest point near its center being at the western end of the drainage tunnel. The maximum length of this territory is about 5½ miles, and its maximum width about 3 miles.

Owing to the rolling condition of the strata, the workings contain many local basins, some of which are of considerable size. A series of open channels or "water ditches" feeding into the drainage tunnel will therefore be necessary before the large area can be thoroughly drained by the tunnel. The territory drained directly, at present, by the tunnel contains 2,488 acres. The additional area to be drained after the completion of the "water ditches" is 4,618 acres, making a total area to be drained of 7,169 acres. Besides this, the areas of some adjoining properties could also be drained by driving additional feeders to the tunnel.

The exact length of the tunnel is 10,679.4 ft., or a trifle over 2 miles. The west portal is at the lowest point in the workings mentioned above, and its east portal in the valley of Preston Run, draining into Braddocks Run, at Clarysville. Braddocks Run is a branch of Wills Creek, which flows into the north branch of the Potomac River. The tunnel is 8 ft. wide and 7 ft. high. Its grade is 0.3551 per cent.

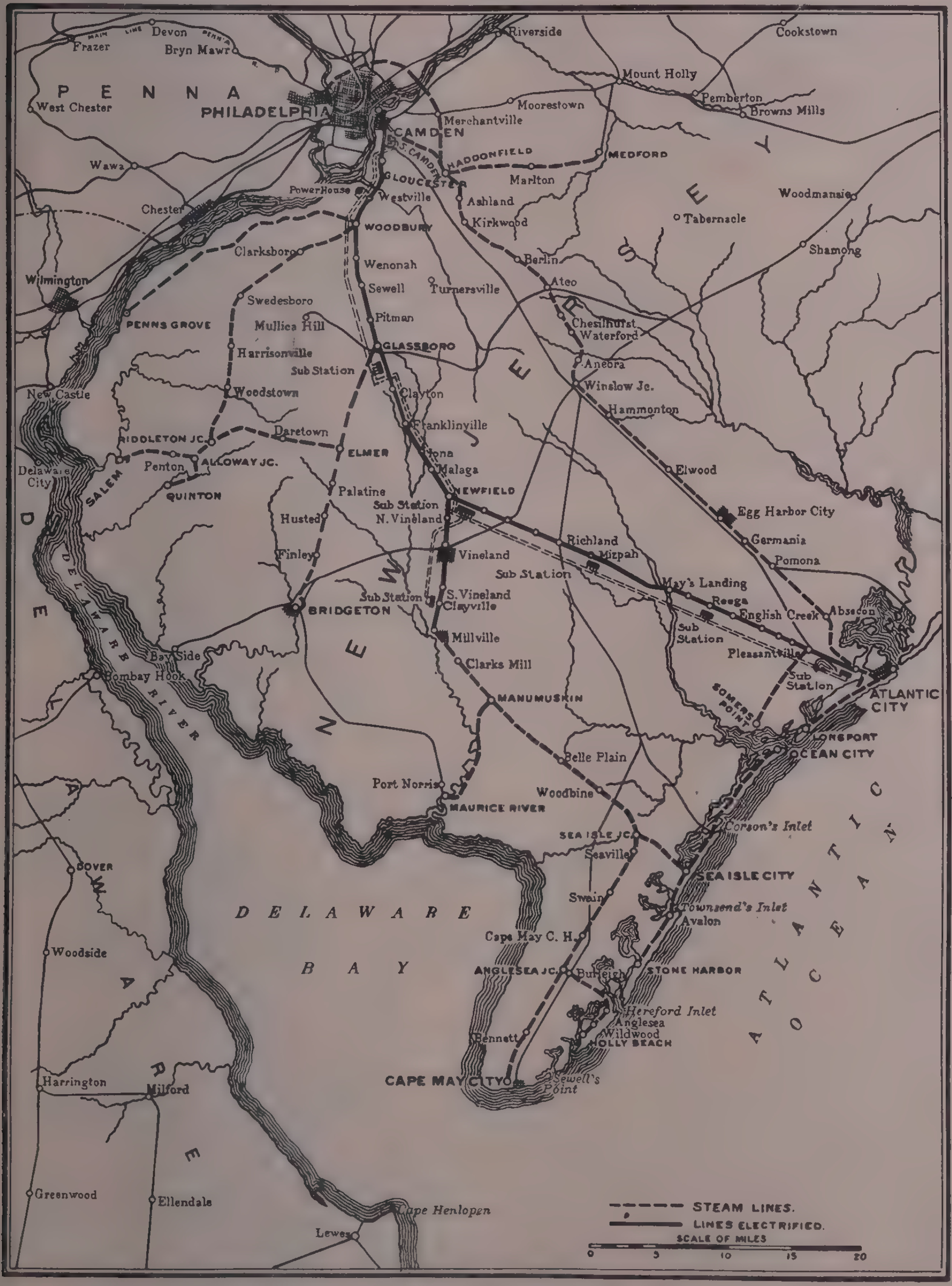
To facilitate the driving of the tunnel, a shaft was sunk near the center to a depth of 174 ft. and headings driven both east and west. At the same time headings were driven from the east and west portals. Work was commenced in November, 1903, and completed in August, 1906. The first 425 ft. of the tunnel from its eastern end was driven on a course of N. 85° 24′ W., and the balance of the tunnel on a course of S. 76° 21′ W., or, measuring in the direction of the flow of water N. 76° 21′ E.

The direct result of this tunnel is the elimination of one of the largest, if not the largest, pumping station in the bituminous coal regions of the United States. The capacity of this station was 7,000 gal. per minute, and was maintained for a number of years at a daily expense of $50. The future advantage to be derived from the driving of this tunnel can hardly be estimated. The work was done from the plans and under the direction of Mr. H. V. Hesse, the company's general superintendent.

THE MANUFACTURE OF PEAT FUEL seems to have been placed on a practical basis by the Lamartine Peat, Light & Power Co., of Fond du Lac, Wis. The peat is removed from a submerged bog by a steel cage 18 x 36 in. x 8 ft. long. This is forced down into the bog and drawn out filled with peat, 40 to 60 tons of peat being taken out per hour in this way. The company at first had difficulty in finding a press which would handle the peat in the wet, soggy state, as it comes from the bog. Finally a special machine was devised which works satisfactorily and turns out about 120 tons of crude fuel in 10 hours. The peat after it comes from this machine is air-dried in open sheds. The finished product contains about 10,781 B.t.u. It can be manufactured for $1.20 per ton, and it sold last winter in Fond du Lac for $6 per ton.

The Electrification of the West Jersey and Seashore Branch of the Pennsylvania Railroad.

The longest main line double-track railroad operated electrically in this country is the West Jersey & Seashore branch of the Pennsylvania R. R., which has lately been changed over from a steam to an electric line in record time. The site for the power station was selected on Jan. 17, 1906, the first piles driven two days later, and on July 1 current was delivered from it to the newly electrified tracks. The electric service was inaugurated on Sept. 1. In the work of reconstruction it was necessary to relay 48.1 miles of track with new rails, build 36.6 miles of new second track and 6.5 miles of new third track, reconstruct stations, put in telephone lines, reconstruct telegraph lines and signal systems, and carry out a great amount of detail work from Camden to Atlantic City, 65 miles, and from Newfield to Millville, 10 miles. All told it was necessary to equip electrically about 150 miles of single track, calling for 71 miles of duplicate high-tension transmission line and eight sub-stations, and to provide 68 special cars.



Map of the West Jersey & Seashore Branch of the Pennsylvania R. R.

The location of the line is shown in the accompanying map. Beginning at Camden an entirely new terminal has been constructed and ¾ mile of double-track steel trestle has been built to connect this terminal with the existing lines, at grade. From a point about two miles from Atlantic City a new right of way has been secured, and after crossing the Thoroughfare on a new drawbridge the tracks cross the Philadelphia & Reading Ry. on an elevated steel structure and enter the Atlantic City terminal on a descending grade. From Camden to Atlantic City the road has been electrified with a third rail, with the exception of a stretch of track 4.4 miles in length between Haddon Ave., near Camden, and South Gloucester, the track passing through the city streets at grade between these points, being equipped with the overhead trolley. In addition to this through route, the line from Newfield to Millville has been equipped with the overhead trolley. From the Camden terminal to Newfield and from Newfield to Millville, the road is laid with 100-lb. rails of the Pennsylvania standard cross-section, and from Newfield to Atlantic City it is laid with 85-lb. rails of the Am. Soc. C. E. section.

It will be noticed on the map that the Pennsylvania R. R. Co. has two roads connecting Camden with Atlantic City, and it is the longer that has been electrified. This has been done because there is a large local traffic on the longer route that can be handled more economically and expeditiously by electric traction than is possible with steam haulage. The importance of the undertaking is further emphasized by the density of the traffic on the electrified section of the road. The power house and sub-station equipment and the line are laid out with a view of supplying sufficient power for the operation of all the cars now provided, operating in an express service to Atlantic City, consisting of three-car trains running on a headway of fifteen minutes in each direction at a speed on straight level track of 60 miles per hour, and for a local service of two-car trains between Camden and Millville on half-hour intervals, and single cars between Camden and Woodbury on ten-minute intervals. The motor, baggage and mail cars are attached to the passenger trains as conditions require. Each car in the electric service is a motor car, no trailers being used.

The contract for the entire electrification work was given to the General Electric Co. and through them certain portions were sub-let. The electrical equipment throughout is of standard General Electric design. Alternating current at 6,600 volts is generated at the power house, where it is stepped up to 33,000 volts. At this latter pressure it is transmitted to the sub-stations, where it is reduced to 430 volts by step-down transformers, and then led to the rotaries and converted to direct current at 650 volts, which is delivered to the third rail.

The Power House.—The power house is situated just north of Westville, and 5.6 miles from the Camden terminal, where there is an abundance of water for boiler and condensing purposes.

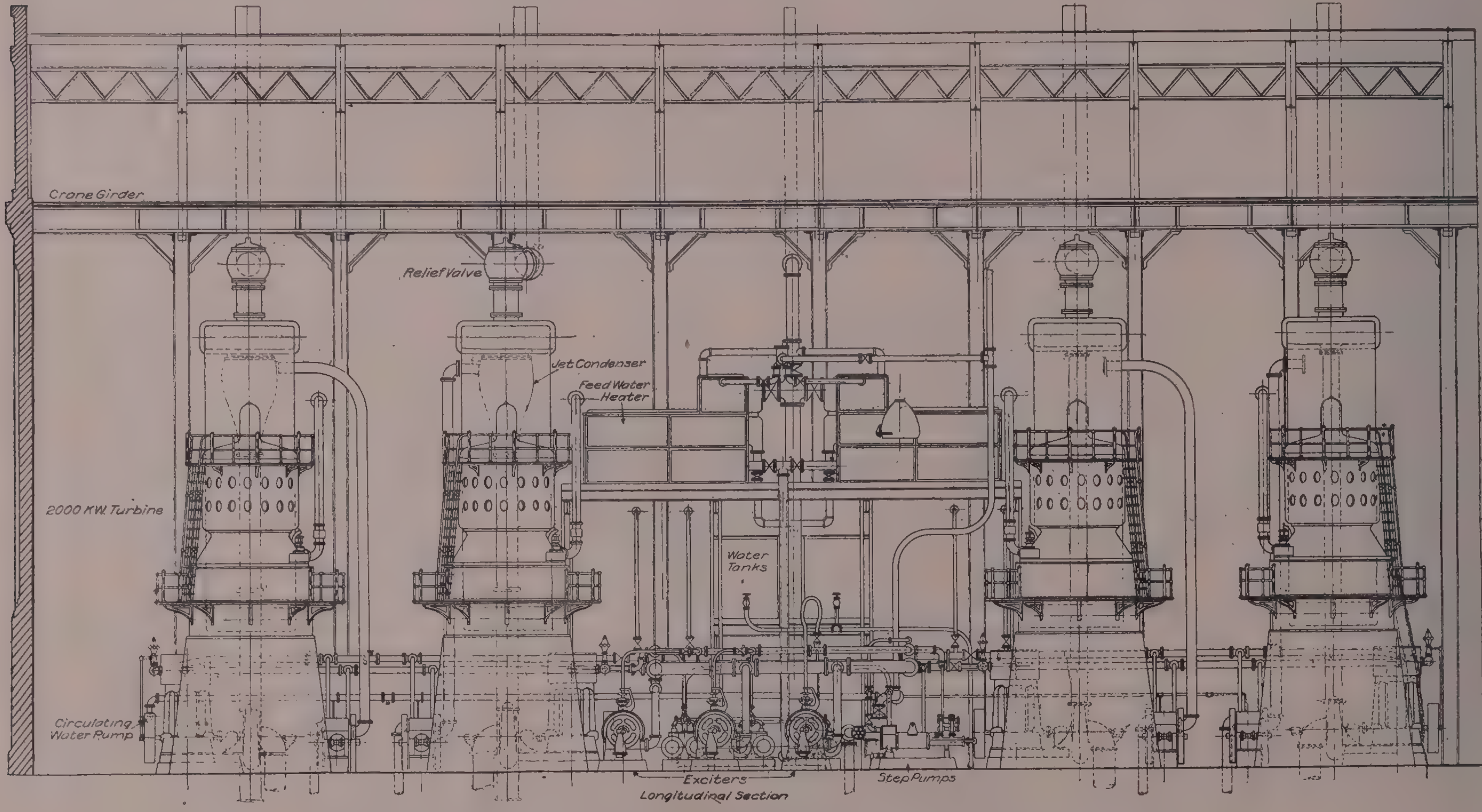
The power house, boiler house and stacks are built on about 850 concrete piles. The foundations, which were started on March 15, are of reinforced concrete and are superimposed upon the piles in such a manner that the latter project about one foot into the mass of concrete, making a thoroughly homogeneous foundation. The boiler foundations were completed March 25, and those for the steam turbines June 5. The erection of the steel work for the main building was begun April 18. On March 5 the foundations for the stacks were started and these were completed by March 25. The steel work for the stacks was started on April 11, and the first stack was erected, lined and ready for use June 29.

The main portion of the equipment of the engine house consists of three 2,000-kw., 6,600-volt, 25-cycle, three-phase Curtis turbo-generators; two 75-kw., 25-cycle, air-blast transformers, with three blowers each of 20,000 cu. ft. capacity per minute, and a switchboard comprising three three-phase generator panels, two exciter panels, three blower motor panels, one synchronizing equipment, three 33,000-volt transformer panels, two sets of lightning arresters and switches, six static potential indicators and two 33,000-volt outgoing line panels. There is sufficient room provided in the layout of the building for an additional 2,000-kw. turbo-generator set, together with the necessary auxiliaries, and the foundation for it is built. In addition one of the end walls of the station is of a temporary nature in order that increasing demands for power may be met by enlarging the station with a minimum of expenditure in the future.

The most important items among the auxiliaries are: Two exciter sets, consisting of horizontal Curtis steam turbines coupled to 75-kw., four-pole General Electric direct-current generators, the exhaust being used for heating feed water; three barometric condensers, rated at 60,000 lb. of steam per hour with a vacuum of 28 in. and circulating water at 70° Fahr., built by Williamson Brothers in connection with Cramp & Co., of

Philadelphia, who were also the sub-contractors for the circulating and air pumps; three dry air pumps built by I. P. Morris Co.; three centrifugal circulating pumps, built by the I. P. Morris Co., and driven by Reeves engines with the exhaust discharged to either the feed-water heater or to the third stage of the turbines, the latter arrangement only being used when the exhaust from the other auxiliaries exeeds that required for the feed-water heater; two Cochrane feed-water heaters, each of a capacity for heating 135,000 lb. of water per hour from 70° to 212°; two Worthington boiler feed pumps, two Worthington make-up pumps, two Worthington step-bearing pumps, three Worthington step-bearing return pumps, and an accumulator for the step bearings with a capacity of 100 gal. of water at 800 lb. pressure, supplied by R. D. Wood & Co.

The area of the power house is 17,069 sq. ft., and the cubic contents amounts to 829,113 cu. ft., thus giving 2.13 sq. ft. and 103.6 cu. ft. per kilowatt as the unit output of the station, based on 8,000 kw. as the ultimate capacity of the present structure. The layout of the steam piping in the power house is of a very neat design and allows ample operating space around all the machinery. Messrs. W. K. Mitchell & Co., of Philadelphia, Pa., were the sub-contractors for this work, together with the steam valves, etc., and Keasby & Mattison furnished the pipe covering.



Longitudinal Section through the Turbine Room of the Power Station.

The boiler house is furnished with 12 Stirling water-tube boilers arranged in pairs forming six batteries. Each boiler is rated at 358 h.-p. and is furnished with a superheater capable of delivering steam at 175 lb. pressure and at 125° superheat.

The coal is dumped from the railway cars into the receiving hopper under the siding. The hopper has a slanting bottom to feed the coal by gravity through a valve which is only opened when the skip is in the correct position for loading. The loaded skip is raised by a hoisting engine till it reaches the level of a deflector, when it is automatically tipped into the crushing hopper, the smaller coal passing through the screen and the larger coal being broken in the crusher in transit. From this hopper the coal is fed into the gravity return car by means of the valve at the bottom, whence it is conveyed by the automatic railway over the coal bunkers, into which it is tipped. From those bunkers it is again fed to the coal cars on the tracks on the boiler room floor. The ashes are raised in a similar manner to the coal, but the dumped into the receiving hopper, whence they are raised in a similar manner to the coal, but the deflector is thrown in the reverse direction from that maintained when handling coal. The ashes are conveyed from the ash chute to the ash storage bin, whence they are discharged through a chute to cars on the siding.

Sub-stations and Line.—The high-tension, three-phase current is stepped down and converted to direct current at 650 volts in eight sub-stations located in the power house at Westville, at South Camden, Clayville, Atlantic City, Glassboro, Newfield, Mizpah and Reega. The equipments in the several different sub-stations vary according to the requirements of the portion of the road they supply.

The rotary converters are all of standard General Electric design, capable of running at 150 per cent. of full load for two hours with a temperature rise not exceeding 55°. The transformers are supplied with taps giving one-third and two-thirds of the working voltage to enable converters to be started from the alternating-current side. By this method any of the rotary converters can be started, run up to full speed and be delivering power to the line within a minute.

Three standard air-cooled transformers are provided for operation in conjunction with each rotary.

The disconnecting switches and lightning arresters in each sub-station are located in a separate room; the high-tension circuits are of bare copper wires supported on insulators on a pipe framework, and each pole of the oil switches is enclosed in a separate brick compartment. In all cases the instruments and oil switches are of General Electric design.

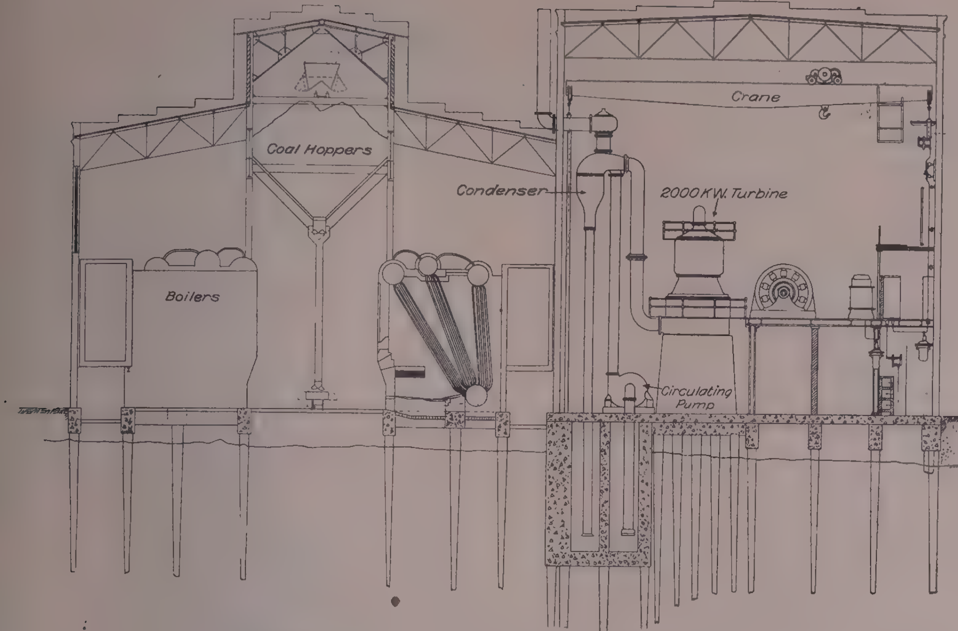
The 33,000-volt transmission line is in duplicate throughout. It is Y-connected with the neutral grounded and consists of six No. 1 hard-drawn copper wires on porcelain insulators. The poles are of chestnut, their height being 45 ft., with extra long poles where special conditions require. They are spaced 125 ft., but at street crossings the spacings are reduced to 100 ft. Head guys are used at distances of approximately one-quarter of a mile. There are two cross arms, the top arm being 12 ft. in length, carrying four insulators and the lower arm, which is 8 ft. 6 in., carries two insulators. The six wires form two inverted equilateral triangles, and the insulators on each triangle are 42 in. apart. The wires in each triangle are transposed by one complete spiral between each sub-station.

A unique feature of the transmission line is the method of protection from lightning, which consists of a seven-strand galvanized steel cable 5/16 in. in diameter, strung for the entire length of the line on top of the transmission poles, 4 ft. above the nearest active wire, and provided with ground connections at every fifth pole. This form of protection from lightning is believed to be an efficient supplementary adjunct to the arresters.

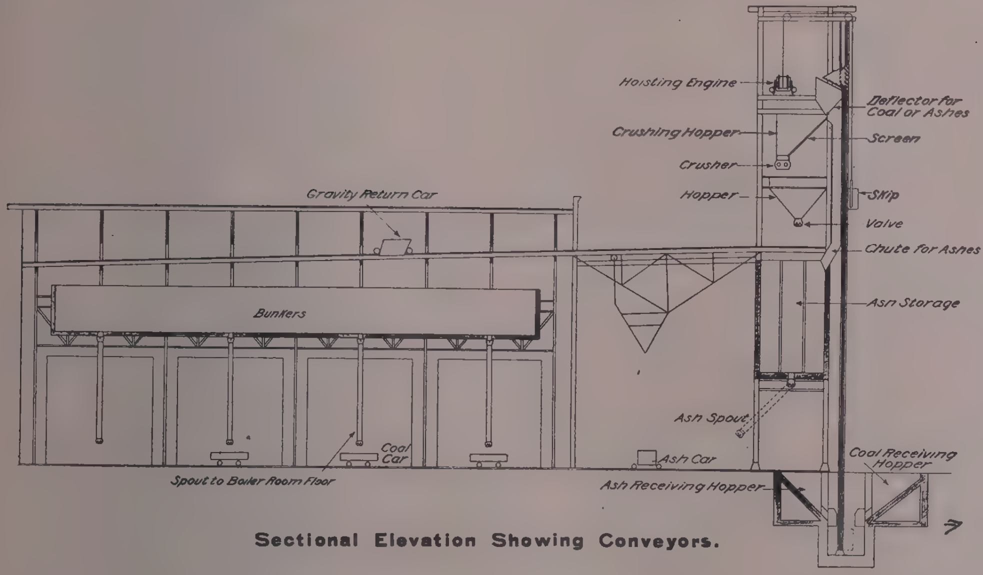
In all there are 71 miles of transmission line. This was erected at a speed of from one-half to two miles a day; the work including the digging of holes and pole erection, besides the stringing of six wires and tying them in position to their respective insulators.

The Third Rail.—The proposition of installing the third rail for the double-track road of this length in the prescribed time demanded a considerable amount of skill on the part of those organizing the work, and the fact that a large amount of steam traffic and double tracking was going on at the same time materially added to the difficulties of the undertaking. The Pennsylvania R. R. Co. provided and installed all the necessary long ties on which the insulators are placed, and they also provided and distributed along the track all the third rail, third rail splice bars and bolts.

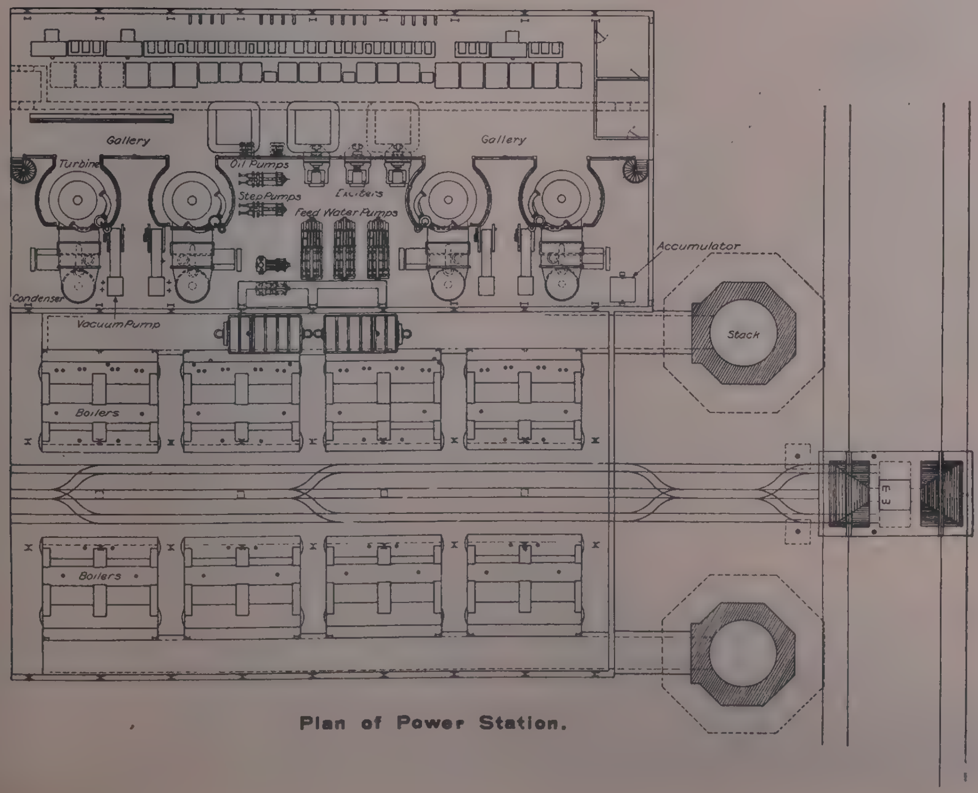
The third rails have the Pennsylvania R. R. standard cross-section and composition; they are in lengths of 33 ft., weigh 100 lb. per yard, and have a conductivity about equal to that of a copper rod of 1,200,000 c.m. This type of third



Cross-Section through Boiler and Engine Room.



Sectional Elevation Showing Conveyors.



Plan of Power Station.

rail was used in order that it might be interchangeable with the track rails.

The insulators are of reconstructed granite, and are held in position by a metal centering cup, which is secured to the long ties by a lag screw. The insulators are 10 in. in length and 5½ in. broad at the base, with an effective depth from the bottom of the rail to the tie of 3½ in. The general form of these insulators may be seen in the illustration of the jumper. An advantage of the method of securing them in position, shown in this drawing, is that on the ties being depressed by the passage of a train no tension strain is brought to bear on the insulators. The insulators are spaced about 8 ft. apart. The top of the third rail is 3½ in. above the top of the track rails, and it is 26 in. from the gauge line of the adjacent track rail, these dimensions constituting the standard of the Pennsylvania R. R. and the Long Island R. R., and are also interchangeable with the Interborough Rapid Transit track in New York City.

The third rail is bonded with concealed ribbon bonds with solid copper terminals compressed into one-inch drilled holes. There are two bonds to a joint, and each has an area of 500,000 c.m. The work of bonding the third rail was accomplished at the rate of 660 bonds per day.

The third rail jumpers are used at all grade crossings and wherever continuous third rail is impracticable. The cable is drawn into a bituminized fibre tube, laid in a solid concrete projection. The illustration shows a double jumper. Terra cotta covers are employed to protect the cable terminals.

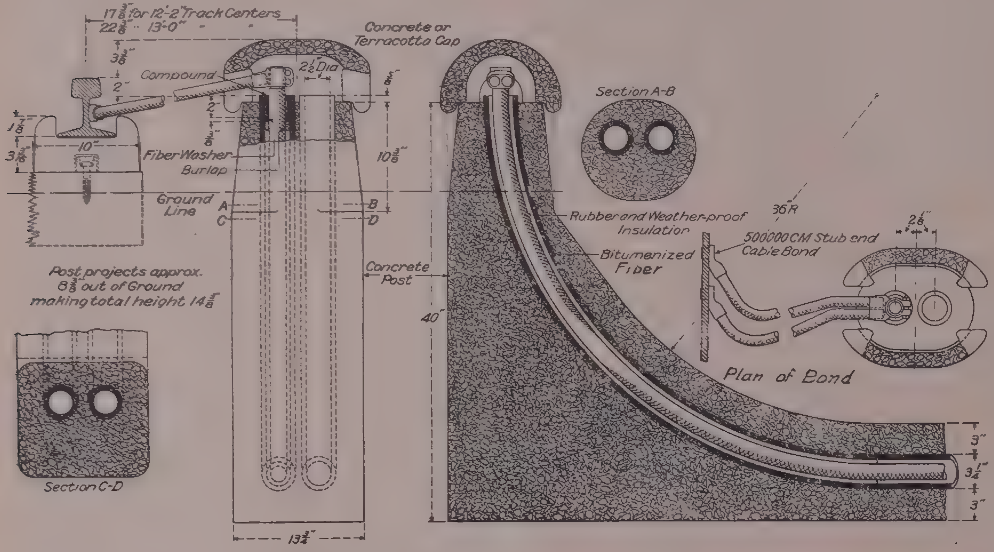
The third rail is anchored at intervals by metal clamps secured to the under flange of the rail in such a position as to engage the insulator on either side. The third rails are arranged in such a manner that each track may be isolated from the other, but normally the third rails are electrically connected midway between the sub-stations through a combined switch and fuse box. There are also section insulators opposite each sub-station so that in the event of an accident on any part of the system only a short section of the third rail would be dead.

At all stations and in the Atlantic City and Camden yards the third rail is protected by a wooden top and side guard. This consists of a 2-in. plank carried on castings attached to the top of maple posts, which are secured to the third rail at intervals of about 6 ft. The top casting is of such form that although it is provided with a web for strength no part of it extends either above or below the protection plank. Opposite all platforms the rail is further protected by a plank fastened to the side of the rail. Wherever possible the rail is kept between the tracks, and is therefore on the side of the track farthest from the station platform, and inter-track fences are provided to prevent crossing the tracks. In order to prevent passengers or others on the platforms from touching the contact shoes on the platform side of the car, there is a protection plank similar to the third rail protecting plank, but carried on castings fastened to the ties. The shoes are at all times under this plank and therefore protected. This is used at all stations, even where the third rail gives way to the trolley, although there is a switch on the car switchboard which enables the contact shoes to be cut out when operating from the trolley.

At Atlantic City, where the tracks cross the Thoroughfare, a new drawbridge has been built. The third rails on this draw are connected to the third rails on the approaches by sliding contact shoes, so that when the draw is closed the rail is continuously connected. In addition to this two 1,000,000-c.m. submarine cables are provided connecting the rails so that the opening of the draw does not interrupt the circuit. The submarine cables for the return circuit are bare.

A point of great interest is to be found in the fact that the third rail system has been adopted at both terminal stations where there are a number of platforms, and it will be interesting to engineers to learn that this system was adopted on the score of less difficulties being encountered in its installation than would have been the case had an overhead trolley been erected.

Bonding.—The bonding of the main track between Camden and Atlantic City was a work of great magnitude, which will be appreciated when it is remembered that a heavy steam traffic was in progress during the whole period. It is a matter of interest to know that all the holes were drilled by hand and also that the bond terminals were expanded by means of screw compressors. Two bonds of the concealed type were used per joint, each with a capacity of 400,000 c.m. and on account of the large size of bonds special angle plates had to be provided. As the road is double track throughout on the main line, the rebonding required the drilling of a prodigious number of one-inch holes. This work was performed almost entirely with untrained labor under skilled foremen. The men were given a royalty of five cents on each hole drilled above thirty per day, and some reach as high a maximum as eighty in a day's work. The railroad company required that one splice bar should always be kept in place against the rail to provide for the safe operation of the passing trains.


17⅜" for 12'-2" Track Centers
22⅜" " 13'-0" "
Concrete or Terracotta Cap
3⅜"
Compound
2½" Dia
2"
1⅞"
3 3/16"
10"
Fiber Washer
Burlap
10⅜"
Ground Line
A
B
C
D
Section A-B
Rubber and Weather-proof Insulation
36"R
2⅝"
500000 CM Stub end Cable Bond
Bitumenized Fiber
Post projects approx. 8⅜" out of Ground making total height 14⅝"
Concrete Post
40"
Plan of Bond
Section C-D
3"
3¼"
3"
13¾"

Insulator and Jumper for Third Rail.

Cars.—For initial service 62 passenger cars and 6 combination baggage and mail cars have been provided. All of the cars are motor cars, the motor and control equipment being the same on all. In preparing the design of these cars the engineers of the railroad followed the general design of the standard Pennsylvania Railroad coaches, except that the height is less than the standard to decrease the weight, the shape of the roof is changed and a few details are different.

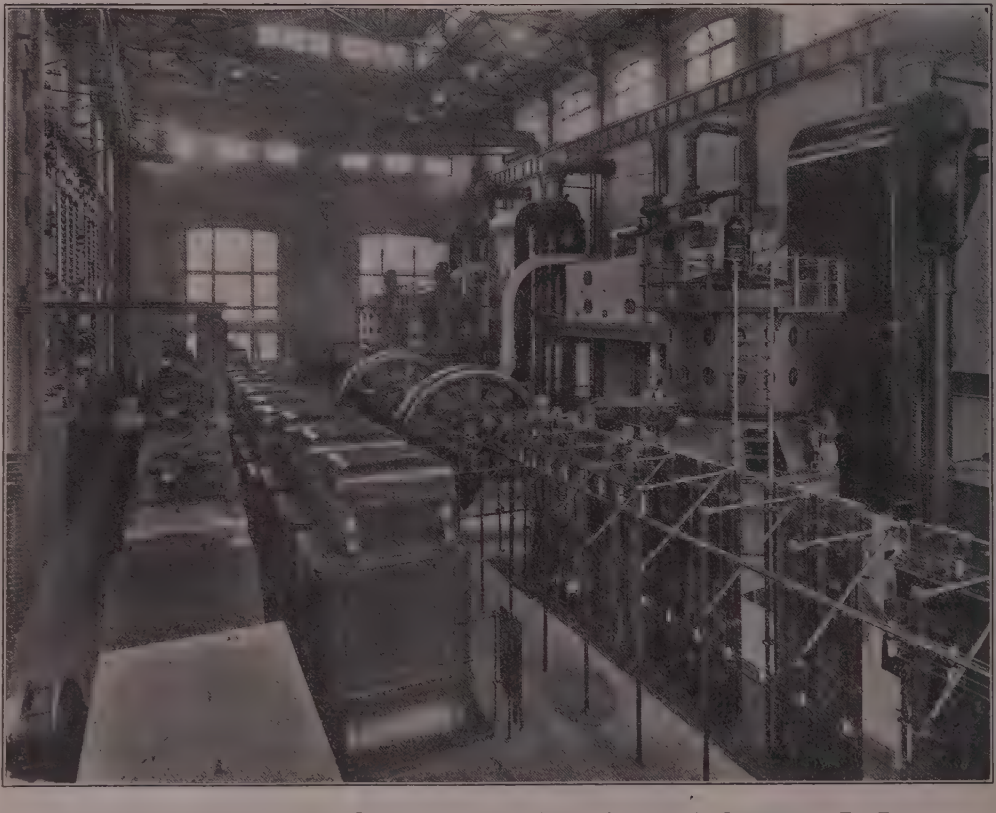
The motor and trailer trucks are of the M.C.B. double side bar equalized type, somewhat similar to those used on the cars of the Interborough Rapid Transit Co. and the Long Island R. R., but with greater wheel base.

The wheels of the motor truck are steel tired with separate cast steel spoke centers. They are 26 in. in diameter with M.C.B. standard tread. Tires are 3 in. thick, shrunk and bolted to the steel center. Schoen solid rolled steel wheels 33 in. in diameter are used on the trailer truck.

The cars are equipped with hand brakes and with Westinghouse quick service automatic air brakes. The motorman is able to divide the process of release into as many steps as may be desired, securing the same flexibility as with straight air. The motor-driven air compressor, with its governor, together with the whistle, are all of the General Electric Co.'s manufacture.

There are two General Electric 69 motors which are 200-hp units on each car, while the control system is of the Sprague General Electric automatic multiple-unit type. The controllers are so arranged that current is cut off from the motors throughout the train and the brakes are applied automatically should the motorman release his hold of the controller handle.

Organization of Work.—The conversion of the lines of the West Jersey & Seashore R. R. from steam to electric traction was carried out by the following organizations:



Interior of the Power Station of the West Jersey & Seashore R. R.

The construction of the terminals, inspection sheds, double tracking, changes in existing tracks, grading, new bridges, changes in telegraph lines and installation of a special telephone system, were carried out by the regular engineering and maintenance of way departments of the Pennsylvania R. R. The installation of the interlocking plants and automatic block signaling was carried out by the Union Switch & Signal Co., in accordance with plans of the signal department of the Pennsylvania R. R. Co. The new cars and trucks required for the electric service were designed by the motive power department of the Pennsylvania R. R. Co. The entire contract for the electrical equipment, including the construction of the power house, sub-stations and the electrical equipment on the cars, was awarded to the General Electric Co., and in accordance with the plans and under the supervision of Mr. George Gibbs, chief engineer of electric traction, in consultation with the officers of the railroad company. Messrs. Stern & Silverman, of Philadelphia, were appointed by the General Electric Co. as their general sub-contractors, and the Scofield Co., also of Philadelphia, acted as general engineers for the power house and sub-contractors for the piling and foundations.

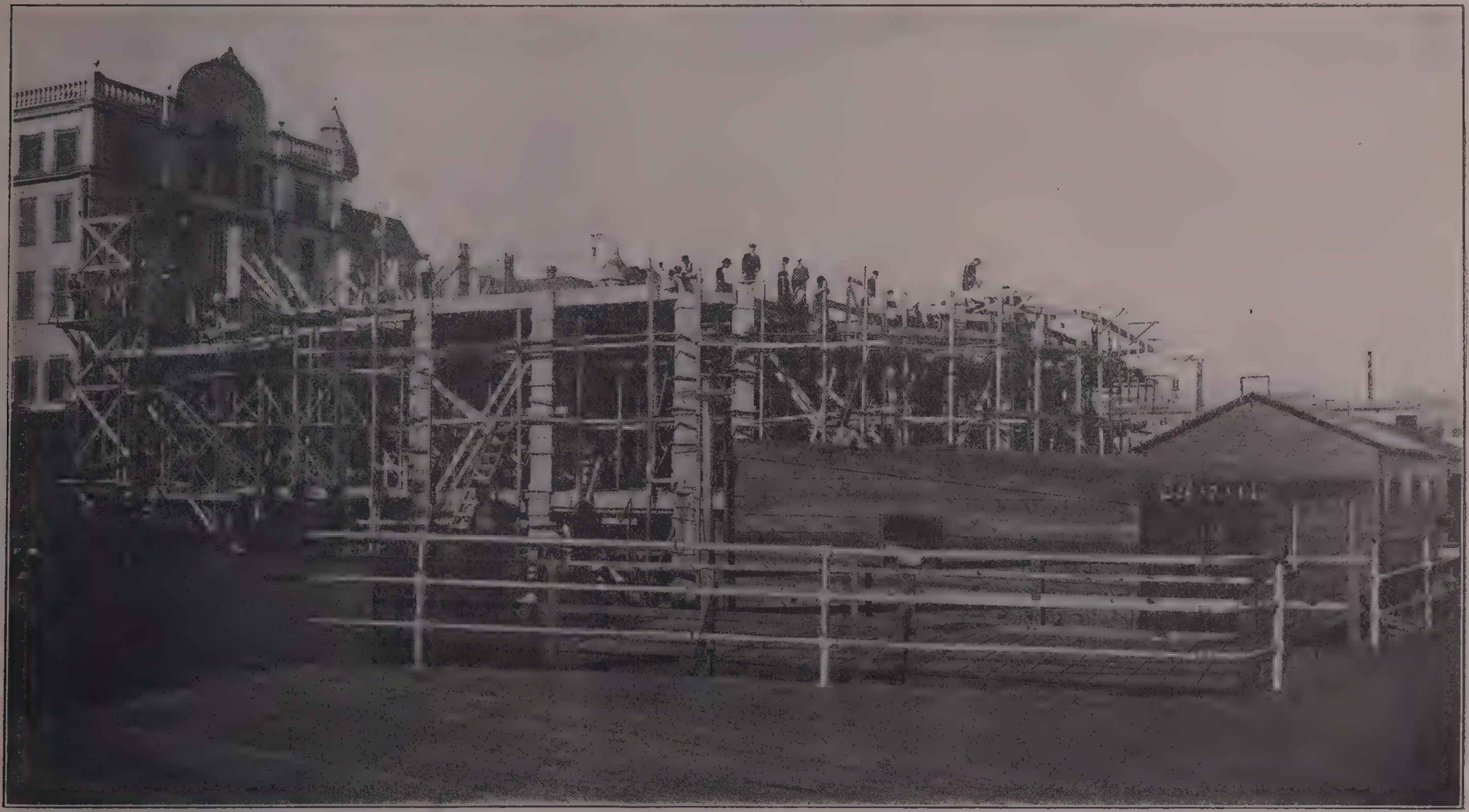
The whole of the electrical work was under the personal supervision of Mr. W. B. Potter, engineer, Railway Engineering Department, General Electric Co., directly assisted by Mr. J. Elliot Hewes, Mr. C. E. Eveleth and Mr. W. H. Clapp.

Decision on a Waterproofing Guaranty.

A waterproofing guaranty in a contract for the foundations of a building was recently interpreted by the United States Circuit Court of Appeals, Third Circuit, 144 Fed. Rep. 942. The specifications forming a part of the contract describe in minute detail the materials to be used and the method of employing them, and conclude with this clause: "The whole to be made perfectly water-tight and guaranteed." After the work was done the cellar leaked badly and payment was refused the contractor on the ground that he had guaranteed the water-tightness of the work. This contention he denied, claiming that all he guaranteed was strict compliance with the specifications, for he could not be held accountable for the results of plans for which he was not responsible. The decision of the court upholds the contractor's contention, for it is to the effect that the guaranty was not absolute, but qualified, extending to the contractor's work only, and only so far as this was involved, to the result.

The Construction of the Hotel Traymore at Atlantic City, N. J.

The Hotel Traymore faces the Atlantic Ocean adjacent to the famous Board Walk at Atlantic City, N. J., and is about to be replaced by a much larger structure built on the original site and extensions of it. The plan of reconstruction provides for the uninterrupted continuation of the hotel business while construction is in progress. To this end, the new building will be erected in two separate portions. The first, about 76 ft. wide, 122 ft. long and nine stories high, is now going up adjacent to the original building, between it and the Board Walk, without interfering with the occupation of the present hotel. After its completion, the guests will be transferred to it from the old building. The old building will then be removed and on its site the remainder of the new building will be erected as an extension to the part now under contract. In this work rapidity of construction, economy, exterior appearance, fireproof construction and the avoidance of undue noise were important considerations and were believed to be well met by the combination of reinforced concrete and hollow tile construction employed, which corresponds essentially with that of the Marlborough-Blenheim Hotel recently built in the same vicinity by the same architects and engineers and described in The Engineering Record of Dec. 23-30, 1905.



View of Work on Lower Part of Traymore Hotel Extension, Atlantic City.

The first floor, proper, of the hotel is at about the same height as the Board Walk, on which it has an entrance, and is about 15 ft. above average high tide. It is called the "exchange" floor, and is supported on basement columns providing a large enclosed space underneath, which is used for storage and other purposes. The "exchange" floor story has a height of 18½ ft., and is surrounded by verandas and communicates with a 33x40-ft. one-story wing or pavilion. The walls are pierced with large arched openings requiring special construction. This story contains the office, parlor, dining-room and other public rooms. The next story above has a height of 12½ ft., and, like all the remaining stories except the top one, is used for guest rooms. From the second to the sixth floor, the stories are uniformly 11 ft. high, and from the sixth to the eighth floor are 10 ft. high. In the eighth story there is a conservatory, and the roof is surmounted by a large concrete dome supported on eight interior columns which, with four other columns, support the floorbeams and girders with maximum spans of 18 ft. The columns and girders are of reinforced concrete, and the floors are made with alternate sections of hollow tiles and reinforced concrete, the latter thus serving not only for the setting of the tiles, but acting also as beams or joists to support the tiles and carry the floor loads to the columns and girders. The exterior walls are made of terra cotta, supported on reinforced concrete girders and cantilevered floor slabs.

The foundation piles are cut off below low-water level, and their tops are bedded in the footings of the concrete piers. The piers were built in sheeted pits kept dry by considerable pumping until the first layer of concrete, enclosing the pile tops, had set. On this layer were placed two crossed tiers of Kahn reinforcement bars, above which the offset pier was built in the usual manner with monolithic concrete deposited in wooden forms.

The columns are both square and octagonal, the smallest dimensions being 10 x 10 in. in the upper story. In the basement the interior columns are 24 in. square, or are octagonal with minimum diameters of 28 in. Both types are reinforced with eight vertical rods ¾ in. in diameter located in the middles of the octagonal sides or in the middles and at the angles of the square columns. In the latter the reinforcement rods are connected by 1½x3-in. horizontal ties, 10 in. apart vertically. In the octagonal columns the reinforcement bars are connected by a spiral wrapping of ¼-in. wire rod with a pitch of 3 in., which makes a complete turn around each bar at every intersection.

Care is taken to make the ends of the vertical bars project about 3 ft. above the floor to bond the columns in successive stories. The wall columns are virtually rectangular piers, and, like the interior columns, their dimensions increase from the top downwards until in the basement a maximum of 26 x 26 in. is attained. Beams and girders are made in the standard manner, reinforced with Kahn tension rods in the lower sides, which project nearly through the supporting columns. Additional Kahn bars about 6 ft. long, reversed so that their prongs point downwards, extend through the columns projecting equally on both sides, and are built into the upper portions of the beams and girders, thus bonding them and providing for cantilever strains at these supports.

The building is proportioned for an assumed wind pressure of 30 lb. per square foot of external vertical surface, and for live loads of 70 lb. per square foot on the "exchange" and eighth floors; all other floors are proportioned for 50 lb. per square foot. The concrete is proportioned for a working load of 500 lb. per square inch in compression, and the reinforcement bars are designed to take all tensile and shearing stress and have a maximum working load of 16,000 lb. per square inch. All concrete is made with Saylor Portland cement and broken trap rock screened to ¾ in. diameter. It is mixed about as wet as it can be without running, and when handled in wheelbarrows makes a quivering mass with the water just flushing to the top.

About one-half of the construction force are carpenters engaged in making the forms, or boxes as they are sometimes termed, for the columns, beams and girders. Boxes are built special for each part of the structure and thoroughly nailed together. After being used they are taken apart completely, the nails drawn, and the timber cut to build boxes for the upper stories. The boxes for the rectangular columns are built with 1¾-in. vertical boards, planed on the inside and on both square edges, fitted tightly together and secured by transverse battens in panels corresponding to the widths of the required column faces. These panels are nailed together through their edges to make rectangular tubes set up vertically on the column centers as required. Like all the rest of the boxes, falsework and centering, they are placed by hand without the use of derricks.

After the column boxes are set over the upper ends of the reinforcement bars which project from the columns in the story below they are provided with rectangular wooden yokes made of four pieces of overlapping 2 x 4 in. timber bolted at the corners. These yokes are large enough to enclose the basement columns and give a little clearance for wedges driven between them and the boxes to insure contact on all sides and maintain the true rectangular cross-section. Besides these yokes, each face of the column is clamped by 2x1-in. U-shaped wrought-iron bars, with the legs projecting over the adjacent sides of the column and secured there by wedging or by wedging and blocking when the clamp is much longer than the width of the column.

Triangular fillets are placed in the corners of all column boxes to chamfer the angles of square columns, and for the octagonal columns are made wide enough to correspond with the column faces. At the foot of each column an open space about 4 ft. high is provided by omitting at first the cover board on that side. Just before concreting is commenced, all dust, shavings and foreign material inside the box is removed through this opening, and it is closed by nailing on the missing length of boards and clamping them in position.

The upper ends of the column boxes are notched to receive the boxes for the floorbeams and girders which are fitted into them, supported on the ends of the vertical boards and on transverse cleats nailed to both members. The ends of the girder boxes are thus set flush with the inner surfaces of the column boxes and, the joints being thoroughly nailed, are considered by the contractors tighter and more satisfactory than when made in any other manner. The girder boxes are simple rectangular troughs, made like the column boxes and supported at intervals between columns on 4x4-in vertical shores with their upper ends double knee-braced to transverse cleats on the bottoms of the boxes.

The floor centering consists of a tight course of 1-in. boards, dressed on the upper side and both edges, which support both the rows of tiles and the intermediate concrete joists. These boards are supported at the ends on the upper edges of the girder boxes and intermediately on transverse joists and vertical shores like those under the girders. The floor tiles adjacent to the girders are thinner than the rest and virtually form parts of the upper portions of the sides of the girder boxes. The difference between their thickness and that of the next tile provides an additional concrete space, and virtually forms a horizontal upper flange for the floor girder, increasing its compressive area.

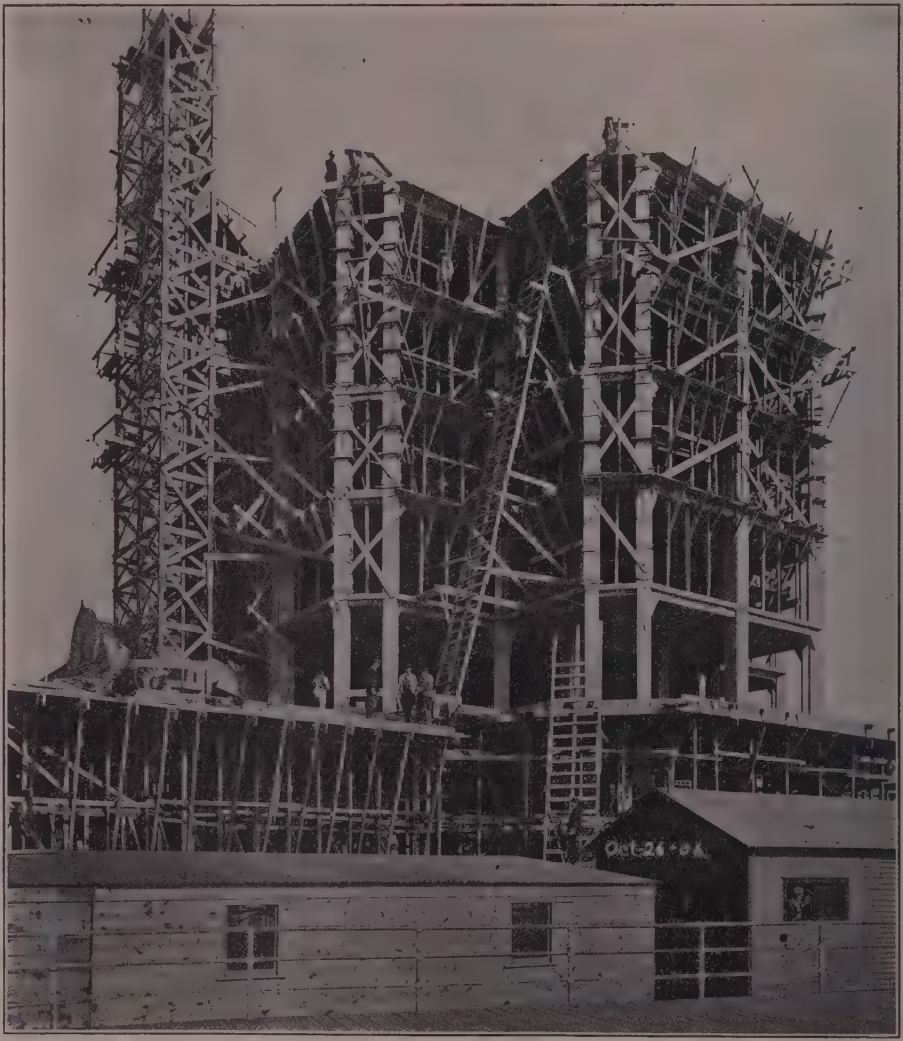
The reinforcement bars for the columns are wired together in the iron yard to make rigid frames with the bars in accurate relative positions and are deposited as units in the column boxes and carefully wired in position. Concrete is wheeled on runways laid on the girder boxes and is dumped from the wheelbarrows into the column and girder boxes. Special care is taken to compact it and work it well around the reinforcement bars and eliminate all chance of empty spaces by constant tamping. In the column boxes long-handle spades with 4x¼-in. blades or simple straight poles are used to work between the reinforcement bars.

In the girder boxes a thin layer of concrete is first spread on the bottom, and then the reinforcement bars are placed accurately on it and moved back and forth until thoroughly set in position, when the remainder of the concrete is filled in and carefully spaded around them. The concrete is leveled off with a straight edge 2 in. above the tops of the tiles, making the floor slabs, the beams, girders and columns monolithic and providing a continuous horizontal surface over the full area of the building, from out to out of walls, about 2 in. below the top of the finished floor. After the concrete has set at least ten days, the boxes are stripped from the columns and girders, the timber roughly cleaned and made up again for use in an upper story. The inner faces of the boxes are scraped clean, but are not oiled or coated with any substance.

Sand and broken stone are delivered by wagons and stored in piles on the ground, from which they are taken as required by wheelbarrows to a slightly elevated platform adjacent to the McKelvey concrete mixer. The wheelbarrows are of two different makes, one with a capacity of 3 cu. ft., and the other with a capacity of 4 cu. ft., and serve to measure the aggregate. The required numbers of loads of stone and sand are dumped over the edge of the platform into a steel hopper and the corresponding number of bags of cement for the required proportion of concrete are added. The dry materials remain stored in the hopper until the concrete mixer has discharged its contents, when the contents of the hopper are delivered to the mixer through a vertical sliding gate and an inclined chute.

The foundation concrete was delivered directly from the mixer to wheelbarrows, but for the remainder of the building the concrete is delivered from the mixer through a moveable chute to the Ransome hoisting bucket, which automatically elevates it to the required floor. This chute is seated on an inclined bed to which it is connected by a lever that can be operated to set the lower end of the chute over the concrete bucket or to slide it back and up so that the lower end clears the bucket, and the latter can be hoisted or lowered past it. The concrete mixer and tower are placed in the most central position available so as to minimize the wheeling distance. Adjacent to it there is a hod elevator on which tiles and other materials are carried. The hoist delivers the concrete to an inclined platform or chute, closed with a gate at the lower end, which is raised to discharge the concrete into the wheelbarrows below.

Pile driving was commenced Sept. 15, since when the work has been vigorously prosecuted by day and night gangs of about 80 men each, and has progressed at the rate of one complete story in six working days, the sixth floor having already been completed. This progress is considered by the contractors to be satisfactory and unusually rapid. Messrs. Price & McLanahan, Philadelphia, are the architects, and Roydhouse, Arey & Co., Philadelphia, are the general contractors. The structural work was designed by The Trussed Concrete Steel Co., of New York, and is being built by the Concrete Steel & Tile Construction Co., Detroit, Mich.



View of Work on Upper Stories of Traymore Hotel Extension.

The Oil-Engine Electric Plant operated by the village of Camden, N. Y., has two units, each a 170-h.-p. Diesel engine running at 200 r.p.m. direct-connected to a 130-kw., two-phase alternating-current Westinghouse generator. Two single-phase, 2,200-volt circuits supply the primary of the incandescent lighting transformers, while the street arc lamps are supplied by a 6.6-ampere constant-current transformer. The average fuel cost for a 10-hour run with 75 arc lamps and a connected load of 2,000 incandescent lamps is said to be less than $2.50.

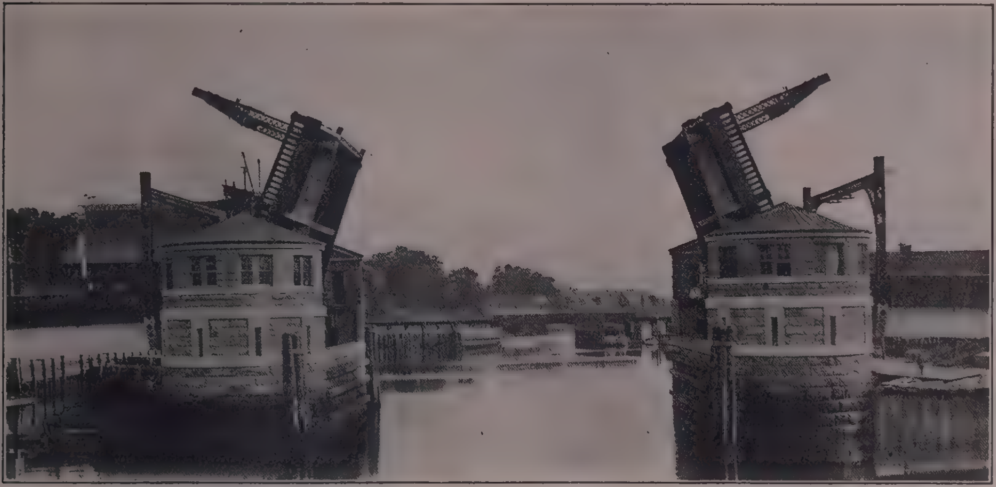
The New Flushing Bascule Bridge.

Jackson Avenue and Broadway in Flushing, N. Y., are connected by a bridge 750 ft. long from end to end of approaches, which has just been built across Flushing Creek, to replace an old swing bridge with a center pier. The former structure was very light and could be operated only with considerable difficulty, and its pier seriously obstructed the narrow channel through which navigation is maintained. An appropriation of $325,000 was made for the new bridge in 1903, and work was commenced in June, 1904, on the construction of an adjacent temporary bridge, completed September, 1904, and used to by-pass traffic while the old bridge was removed and the new one constructed.

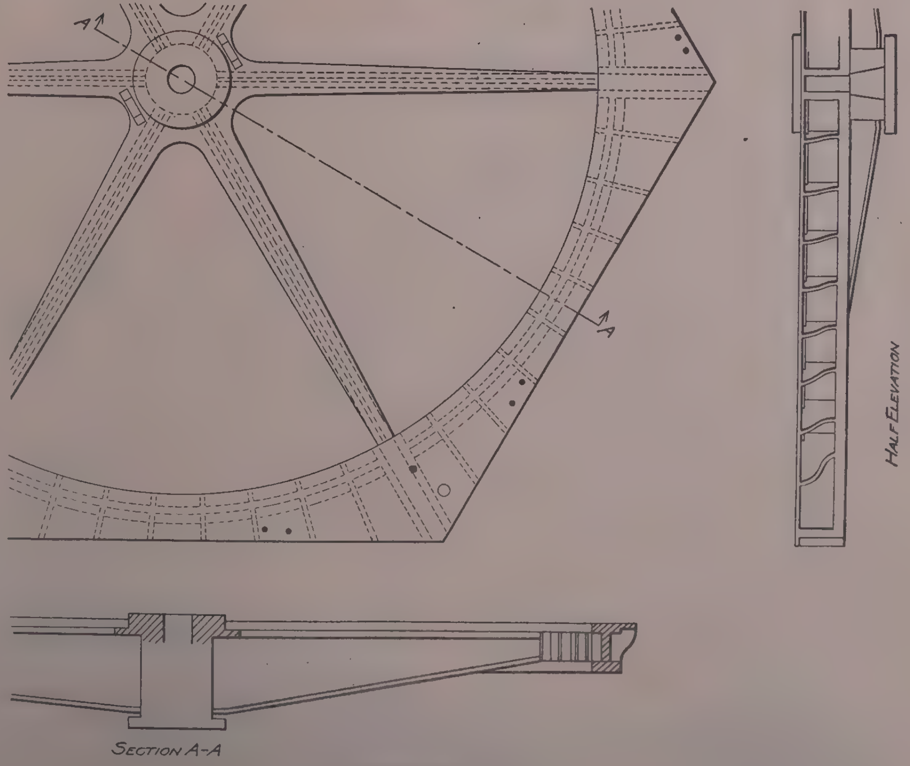
The temporary bridge consisted of a pile trestle with a 128-ft. plate girder swing span, which, except the turntable, was a new span designed to keep the roadway grade as low as possible.

The two main girders, 23 ft. apart on centers, were web-connected to 24-in. I-beam floorbeams 18 ft. apart, which carried 15-in. I-beams under the track rails and intermediate 8x16-in. joists supporting the plank floor about 3 in. in the clear above the top flanges of the main girders, beyond which it projected for the cantilever sidewalks. The three center floorbeams had their lower flanges seated across a hexagonal cast-iron drum with diameters of 31 ft. 4 in. and 24 ft. 6 in.

The drum, which had been previously used in another highway swing span, was of unusual construction, with an irregular I-shaped cross-section having a 2-in. web and an unsymmetrical top flange of varying width, stiffened by vertical webs as indicated in the accompanying drawings. The 8¼-in. bottom flange was 3 in. thick and served as the upper track for twenty cast-iron wheels 20 in. in diameter. The vertices of the hexagon were connected by radial arms integral with the pivot bearing. The drum was centered on a hollow cast-iron pin 11 in. in diameter, with a horizontal bottom flange securely bolted to the pier. It was considered necessary to keep the grade of the bridge as near low water level as possible and this arrangement enabled the turning mechanism to be very compact and reduced the distance from the floor to the top of the pier to 6 ft. 9½ in., thus enabling the floor to be kept 15 ft. above mean low water. The draw was operated by hand and the total cost of the temporary bridge was $31,000.

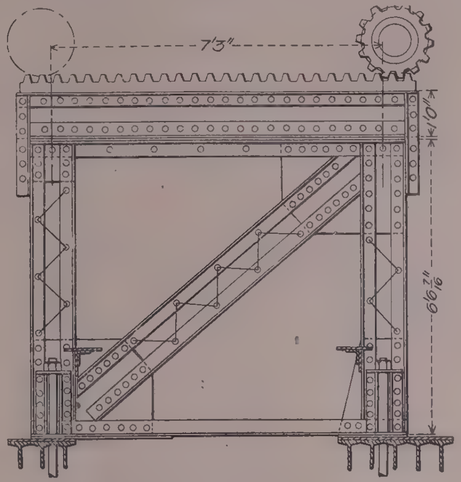


Center Span and Towers; Temporary Draw Span in Background.



Cast Iron Drum.

The approaches of the new structure are solid fills 100 ft. wide with grades of about 3 per cent. to the shore lines, where they are retained between the wing walls of the massive abutments. Between the approaches, the structure consists of a double-leaf Scherzer rolling bascule of 60 ft. clear span and one 68-ft. span flanking it on each side. This portion of the bridge is 52 ft. wide carrying two electric car tracks, two driveways and two 8-ft. sidewalks at a height of 20 ft. above low water level. The two channel piers supporting the bascule leaves are of massive masonry construction rising above the roadway level to provide for operating rooms and toilets, and were specially designed to give an attractive appearance to the structure and combine artistic treatment with the useful features of the work. It is considered that this result has been secured and that the bridge presents a more satisfactory appearance than most bascule or swing bridges.



Operating Pinion and Fixed Rack.

At the bridge site, the bottom of the river is composed of deep soft mud overlying harder strata. There is a maximum tide of about 14 ft. and a mean tide of 7 ft. The channel was dredged to a minimum depth of 12 ft. at low water and foundation piles were driven to hard bearing at a maximum depth of over 60 ft. The tops of the piles are enclosed in the concrete footing deposited under water in sheet pile cofferdams which were afterward pumped out, allowing the granite and limestone masonry to be built dry in them. The abutments are 100 ft. long and about 13 ft. above high water level. The two main piers are 82½ ft. long and 26 ft. wide above the footings with semi-circular ends. The footings are of concrete and the exterior is of rock-face granite with a six-cut coping 8 ft. above water level.

The superstructure is of ordinary construction except that the bascule leaves are operated by a method differing from that generally employed in this type of structure, where the rolling motion is secured by a horizontally moving operating strut engaging the pivot on the main truss or girder. Here the pivot itself is provided with a pinion engaging a horizontal fixed rack. When this is revolved, it pulls the pivot backwards and forwards on the rack corresponding with the displacement of the pivot by the revolution of the girder on its curved track. In this arrangement the driving mechanism is fixed relative to the bascule leaf and moves with it. Each leaf of the bascule has a total weight of about 242 tons and can be opened in 30 seconds by a 25-h.-p., 550-volt General Electric motor using from 10 to 15 amperes for the operation.

The principal quantities include about 6,000 cu. yd. of concrete, 1,000 yd. of limestone and 6,000 cu. ft. of granite in the sub-structure, and 571,000 lb. of steel in the fixed span, 343,000 lb. in the bascule leaves, 35,000 lb. of machinery, 2,300 lb. of track plates and 404,000 lb. of cast-iron counterweights. Construction of the permanent bridge was commenced in May, 1905, and was completed in October, 1906. The bridge was designed by the Department of Bridges, while Mr. George E. Best was commissioner, and Mr. O. F. Nichols chief engineer, and its construction was completed during the administration of Mr. James W. Stevenson, commissioner; Mr. C. M. Ingersoll, chief engineer; Mr. O. F. Nichols, consulting engineer, and Mr. E. A. Byrne, engineer in charge for Queens Borough.

The general contractors were the Snare & Triest Co., Mr. Frank Miller, chief engineer. The steel work was fabricated at the Trenton plant of the American Bridge Co., and was erected by the general contractors. The estimated cost of the bridge was $257,844, and its formal opening, on Oct. 17, was celebrated by ceremonies and addresses by New York City officials and by the Business Men's Association of Flushing, who tendered a reception to their guests.

Accidents to Gas and Oil Engines.

The report for 1905 of Mr. Michael Longridge, chief engineer of the British Engine, Boiler and Electrical Insurance Co., of Manchester, England, contains an instructive section on the accidents to gas and oil engines observed during the year. The rate of breakdown was decidedly lower than in 1904, and lower than among steam engines, but this statement is qualified in significance by the fact that the gas engines insured are mostly small and, in the present stage of gas engine design and construction, are more reliable than those of greater power. The accidents may be classified according to the parts believed to have given way first as follows: Valves and valve gear, 30.1 per cent.; cylinders and cylinder ends, 15.9 per cent.; pistons, 6.2 per cent.; connecting rods and bolts, 10.6 per cent.; main shafts, 15.9 per cent.; governors and governor gear, 5.3 per cent.; mufflers and exhaust pipes, 5.3 per cent.; flywheels, 3.5 per cent.; bolts, 2.7 per cent.; frames and pedestals, 0.9 per cent.; main driving ropes or belts, 0.9 per cent.; starting gear, 1.8 per cent.; gas producer plant, 0.9 per cent. The causes of the accidents may be roughly classified as follows: Due to accidents or unascertained causes, 44 per cent.; negligence of owners or attendants, 18 per cent.; old defects and wear, 13 per cent.; weakness, faulty design or bad workmanship, 25 per cent.

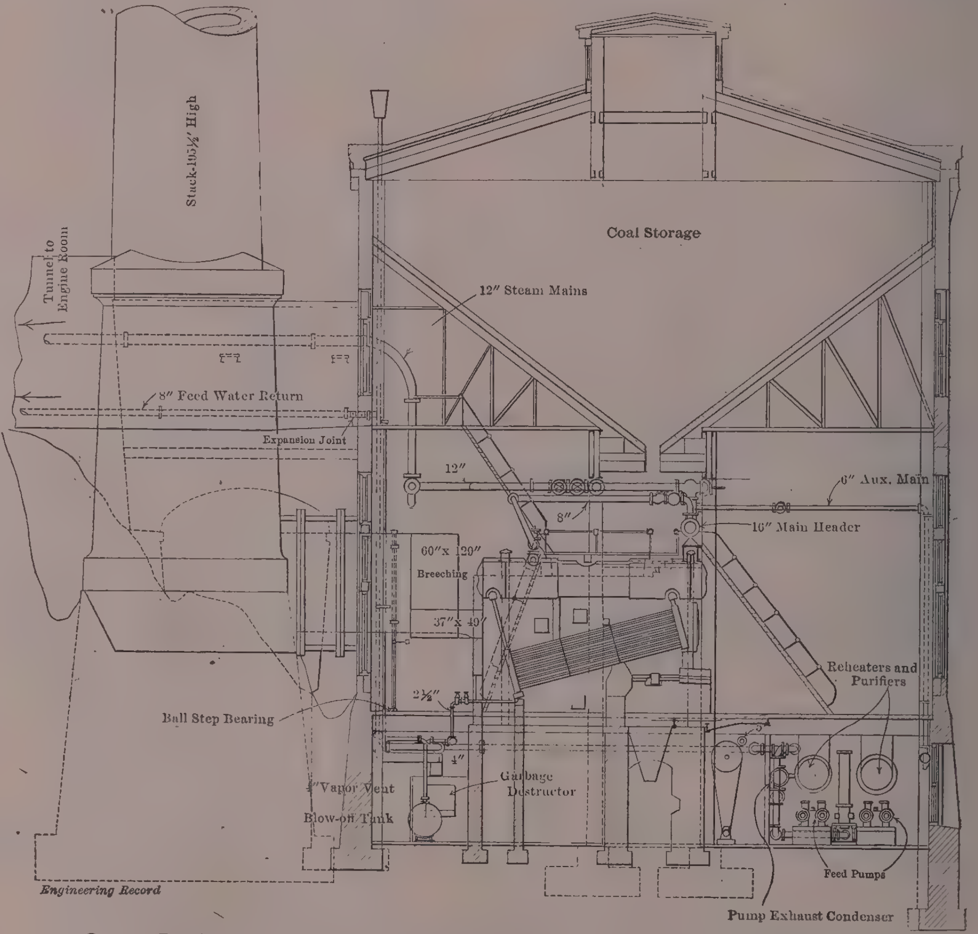
Of the breakages of valves and valve gears 80 per cent. can be classed under three headings only, viz.: Valves and valve spindles, 29.6 per cent.; helical wheels driving side shafts, and brackets carrying shafts, 23.6 per cent.; levers for working valves, 26.5 per cent. Stronger spindles, as far as possible without screw threads or large holes for split pins, better lubrication, and prevention of end movements on side shafts, and stronger levers for working valves, would materially contribute to the reliability of gas engines in Mr. Longridge's opinion.

Cylinders and cylinder ends are being improved, and forms and material which will stand high pressures and temperatures for long periods will, it is hoped, be found in course of time. The only general suggestion made is that all cylinders should be provided with cleaning doors giving ready access to every part, and that ample provision for cooling should be made. The cooling tanks supplied are often inadequate.

Nearly all of the breakdowns attributed to connecting rods resulted from fractures of the bolts in the big ends. These bolts, in the majority of cases, are undoubtedly too weak.

Many gas engine crank shafts fail from weakness, others from carelessness in adjusting the bearings and in keeping them in alignment where there are more than two, and some, probably not very many, from brittleness of the material. Of the shafts that broke during 1905, 50 per cent. had two bearings, and 50 per cent. more than two; and as regards flywheels, 33 per cent. had two flywheels, and 67 per cent. had one flywheel. Of the shafts with two bearings, 22 per cent. broke in the crank arm next the flywheel, 23 per cent. in the crank pin, and 55 per cent. in the neck between the crank and the flywheel. Of those with more than two bearings, 78 per cent. broke in the neck between the crank and the flywheel, and 22 per cent. in the crank arm next the flywheel.

As a very large proportion, probably something like 75 per cent. of the gas engines insured, have only two bearings, the preceding figures show that the third bearing plays no small part in the destruction of the gas engine shaft. The same remark may be made with regard to single flywheels. The principal resistance to the motion of the gas engine piston is due to the inertia of the flywheel, and consequently the stress on the shaft is due principally to the flywheel; if, therefore, the necessary weight be divided equally between two flywheels, one on each side of the crank, the intensity of stress on the shaft is halved. Mr. Longridge further points out that the flywheels of gas engines should be very carefully balanced, especially if they are overhung, otherwise their oscillations may bring heavy stresses on the crank pins. It may be noted that the crank pins which broke belonged to engines with two overhung flywheels.



Cross Section of Boiler House Showing Connection to Piping Tunnel.

The Annual Consumption of Tin has increased in the United States to 40,000 tons and 90,000 tons in the whole world. About one-half of this is used in the manufacture of tin plate and solder.

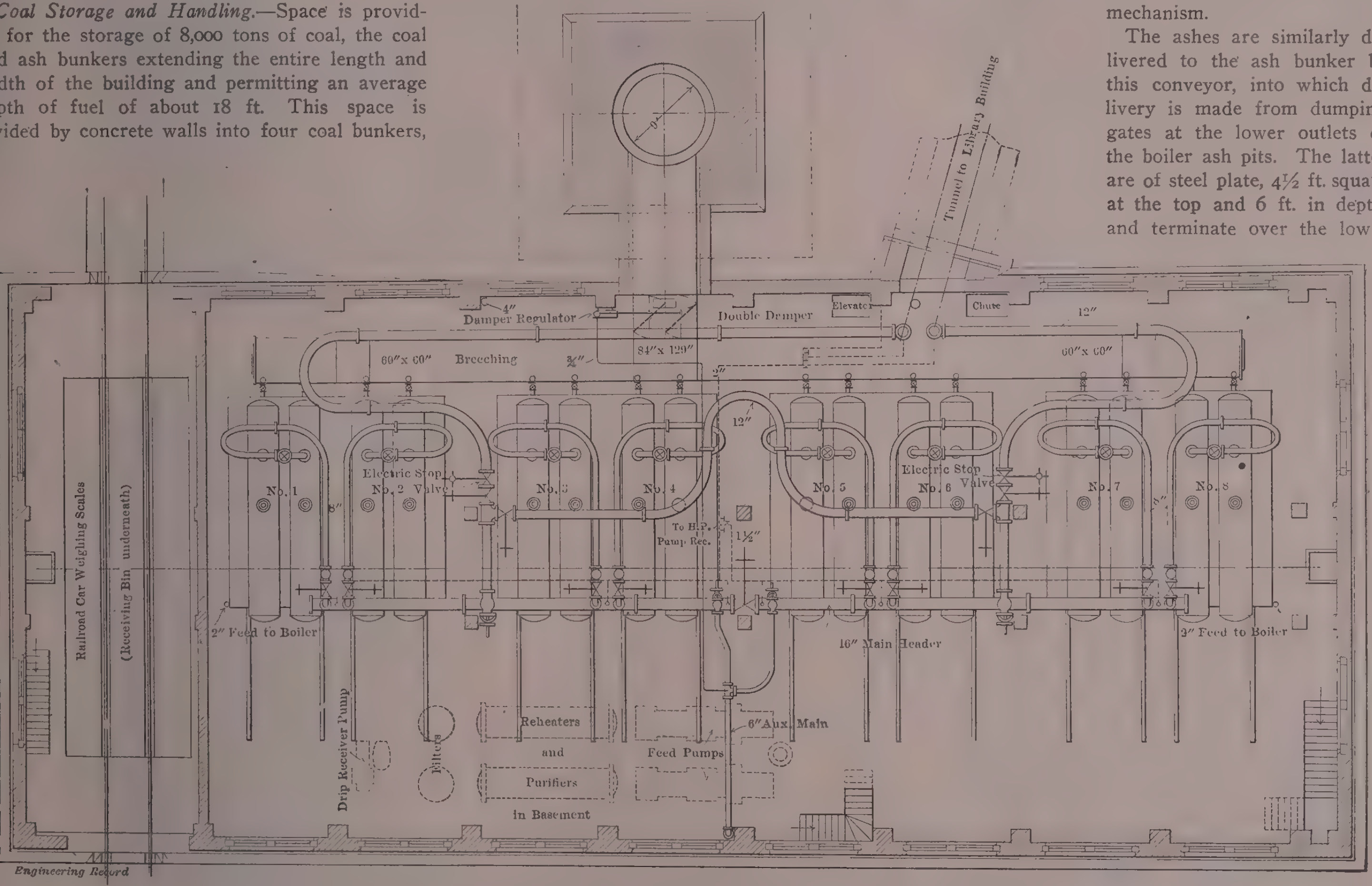
Mechanical Equipment of the Carnegie Library Extension, Pittsburg, Pa.—IV.

The Boiler House.—The power plant is one of the largest ever installed in a public building, having a rated capacity of 2,500 h.-p. in boilers, 2,200 h.-p. in electrical generating machinery and an extensive equipment of pumping and elevator machinery. The installation is notable for the universal use of the most expensive apparatus and fittings, for its convenient and workable arrangement, and for the unusually attractive and comfortable engine and machinery rooms. The arrangement is unusual in that the engine and machinery room, in the central portion of the basement of the library building extension, is about 500 ft. distant from the boiler plant, which have been placed away from the main building to keep the dirt and noise of handling fuel and ashes as far from the library as possible. Fortunately the library was in proximity to a ravine extending past the rear and east side of the building, and it was possible to locate the boiler house in this ravine in such a manner that only the chimney would be noticeable from the library grounds, piping connections being made through a tunnel.

The bottom of the ravine is occupied by the Baltimore & Ohio R. R., but a site for the boiler house was secured part way up the slope on the side toward the library, where a level plot was blasted out of solid rock. The site was chosen at a level low enough to permit constructing a spur from the adjoining railway for coal cars. The boiler room is about 60 ft. below the grade of the library site, and the brick stack rises 195 ft. above the boiler-room floor. The stack is back of the boiler house. A 7½x12-ft. tunnel 32 ft. above the boiler-house floor was driven through the rock to contain the pipes for delivery of steam to the engine room and return of condensation from the heating systems.

The boiler house is a brick and steel structure with concrete floor, roof and coal bunker. It is 65x150 ft. in plan; it has a 12-ft. basement, a main floor with 30 ft. clear headroom and a height from main floor to eaves of 58 ft. The entire upper portion of the structure is devoted to continuous coal bunkers, which are carried on the side walls and two lines of columns, 12 ft. apart in the middle, between which the delivery outlets project. The sides of the bunkers, which are of concrete, slope about 40 deg., and are continuous from base to side walls. Light and ventilation above the entire bunker are supplied by a roof monitor, which also contains the coal conveyor. Access to elevated piping connections is afforded by an extensive system of steel grating platforms, connected with a gallery at the tunnel entrance at the rear by a convenient stairway. This gallery is carried throughout the entire length of the building at the rear. The interior of the building is attractively finished with white enameled brick on both floors.

Coal Storage and Handling.—Space is provided for the storage of 8,000 tons of coal, the coal and ash bunkers extending the entire length and width of the building and permitting an average depth of fuel of about 18 ft. This space is divided by concrete walls into four coal bunkers, each extending 30 ft. lengthwise of the building. The remainder of this space is an ash pocket of 15 ft. clear inside length, holding about 1,000 tons. The inclined side walls of the bunkers are of reinforced concrete, and are carried by triangular trusses between the center columns and the outer building walls. In the space between the two center lines of columns the bunker outlets project, and to these are attached inclined delivery spouts which bring the coal forward to the fronts of the boilers. There are sixteen of these spouts, two to each boiler, which terminate in cut-off gates above a trolley runway which carries two sets of weighing hoppers. These hoppers are each of 1,000 lb. capacity, consisting of scale hoppers suspended in weighing mechanism carried by four-wheel trucks which run on channel runways. The hoppers have downspouts projecting over the stoker hoppers, and may thus be run in front of any boiler and coal weighed out of the bunker above, directly into its stoker, or coal taken from any of the bunkers may be transferred to any of the stokers by traversing the weighing hopper. The car is moved on the runway by a gear operated from the firing floor by a chain. The weighing lever mechanisms are suspended to within convenient distance of the floor and enclosed in cases of the "banjo" type.



Plan of the Boiler House for Carnegie Library Extension Power Plant.

Coal is delivered to the plant in hopper-bottom cars on a siding which passes transversely through the south end of the building at the boiler-room level. Underneath the receiving track in the building there is a concrete hopper into which the coal is dumped from the cars, this hopper holding an entire car load. The section of the track over it, 42½ ft. in length, is suspended upon scale beams to provide for weighing the coal cars as received, the section of track and weighing mechanism being suspended from the steel frame-work of the building above. A scale beam at one side of the room permits of easily weighing the coal car as received and again after dumping the coal into the receiving bin, the tare weight of the empty car, from which figures the net receipts of coal are secured. Underneath the receiving hopper is located a McCaslin single-roll coal crusher through which the coal is passed before entering the bucket elevating conveyor. This crusher has a single roll which works against a corrugated breaker plate, the latter being pivoted and held against the roll by heavy counterweights. Coal is reduced in size by this, but the action of the counterweighted plate is such that pieces of iron or other foreign material, which may be accidentally delivered into the crusher, will be passed through, merely forcing the counterweighted plate away from the roll, and thus not damaging the latter or the driving mechanism.

The conveyor is of the McCaslin overlapping gravity bucket type and encircles the entire boiler house longitudinally at the center. The lower run passes directly underneath the ash hoppers, and the upper run through the roof monitor above the coal bunkers, the vertical legs of the system passing up the end walls of the building, enclosed in steel casing for preventing escape of dust into the boiler room. The driving mechanism is at one end of the upper run, above the ash bunker, and consists of a motor which operates the conveyor link pinion through triple gear reduction. The slack tightener is located at the corresponding end of the lower run, beyond the coal crusher. The horizontal runs of the conveyor are 30-lb. T-rails, supported on special cast-iron chairs. The buckets are automatically dumped on the upper run by an adjustable tripping mechanism which is carried on a track underneath the conveyor track; it is of the cam type, and permits continuous dumping of the buckets at any point of the upper run desired. The upper runway is supported, together with the dump block runway, by cast-iron chairs of special construction, carried in the roof monitor. On either side of the runway at this point there is a platform giving access to the conveyor mechanism.

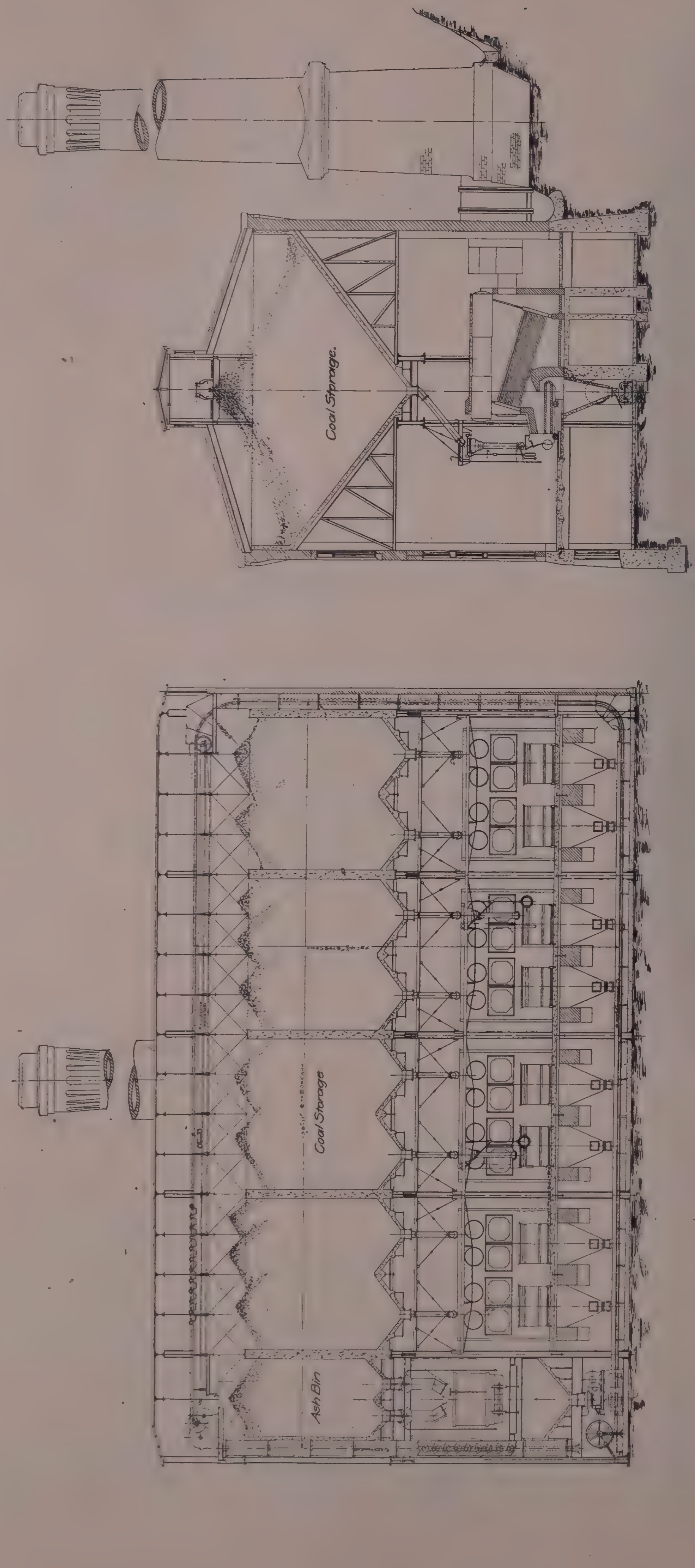
The ashes are similarly delivered to the ash bunker by this conveyor, into which delivery is made from dumping gates at the lower outlets of the boiler ash pits. The latter are of steel plate, 4½ ft. square at the top and 6 ft. in depth, and terminate over the lower conveyor run with under-cut gates. The steel has a reinforced concrete lining 3 in. thick, and clean-out openings are fitted near the base for access to the interior in case the ashes become lodged. Conveyor runway guards are provided over the tracks of the lower run to protect the conveyor link wheels from ashes falling into them; this protection extends the entire length of the lower run underneath the boiler ash pits. The ashes are delivered to the ash bunker at the end of the building over the receiving track, from which they may be chuted directly into cars. The ash bunker has a divided bottom with two delivery chutes by means of which the load may be properly trimmed when filling a car. The chutes are fitted with undercut gates, operated from the floor below. The weighing scales in the receiving track are of convenience in weighing out ashes.

Boilers.—There are eight 309-h.-p. Babcock & Wilcox water-tube boilers, designed for a working pressure of 160 lb. They are set in four batteries of two each, with 6-ft. spaces between for access to cleaning doors, and have a 24-ft. firing floor at the front with 11-ft. space at the rear for breeching and blow-off piping connections. The steam drums and tube sections are flexibly hung in suspensions from above. The side and rear walls are 12 in. in thickness; those at the side are lined with fire-brick, and at the rear of the furnace there is a 36-in. solid fire-brick bridge-wall. The tops of the steam drums are covered with 2-in. magnesia blocks supported on wire netting to form a 2-in. air space. The boiler fronts are finished with white enamel brick to correspond with the interior of the building, which makes the interior most attractive.

The boilers are of the maker's standard heavy pressed type, with wrought steel headers. Each boiler has 144 4-in. tubes 18 ft. in length, arranged in sixteen-tube sections, each nine tubes high. The total heating surface of each boiler is 3,051 sq. ft. Each boiler has two steam drums, 42 in. in diameter by 23 ft. long, and a 12-in. cast-iron mid drum tested to 400 lb. Each boiler has 8-in. delivery nozzles and two 4-in. nickel-seated safety valves set for 160 lb. The Williams feed-water regulator is used in the gauge column for the automatic control of the water level.

The boilers have 7x7½-ft. furnaces in which are fitted Greene chain grate stokers, each of 52 sq. ft. grate area. They have the grate gear mounted on a cast-iron framework, removable from the boiler setting, and have adjustable drives for varying the grate speed, and consequently the rate of combustion. The stoker mechanisms are driven from a shaft underneath the firing floor, operated by a 6x9½-in Kreibel engine, the drives consisting of a ratchet and pawl mechanism on each stoker which is reciprocated by a connecting rod from an eccentric on the driving shaft, with a 12-in. throw; the adjustment of driving speed is secured by changing the radius of the point of the pawl connection to the reciprocating rod. The products of combustion are delivered to the stack through a rectangular breeching, built up of No. 8 wrought iron with heavy angle-bar corners, which extends longitudinally through the building at the rear of the boilers with a connection to the stack at the middle. The boiler connections are 37x49 in. in size and are fitted with balanced dampers. The breeching increases in size toward the middle of the building, entering the stack as a 7x10¾-ft. flue. In the main stack connections there is a set of double vertical dampers, mounted on ball step bearings below the casing, the opening of which is controlled through a Kieley Climax damper regulator operated from the steam pressure. The stack is of radial brick construction, with a 9-ft. opening and riser to a height of 195½ ft. above the boiler-room floor; it was built by the Alphons Custodis Chimney Construction Co.

The boiler feeding equipment consists of two pumps in the basement which return condensation from the heating system and steam-using machinery to the boilers, make-up being supplied from the city mains. They are compound duplex Wilson-Snyder steam pumps, with 8 and 14x8x18-in. cylinders. They are of the outside-end-packed plunger pattern, brass-fitted for handling hot water, and are cross connected in both suction and delivery connections for interchangeability. The feed water is heated in two Warren Webster open heaters which, for convenience of connection to the exhaust system, are located in the engine room in the library basement, delivery to the boiler house being made through the piping tunnel. These heaters are both of the Star vacuum type with connections to the vacuum pumps of the exhaust steam circulation system to prevent air binding, and each is of 1,500 h.-p. capacity. All feed water is delivered to the boilers through, first, a Gunning filter, next a Gun-

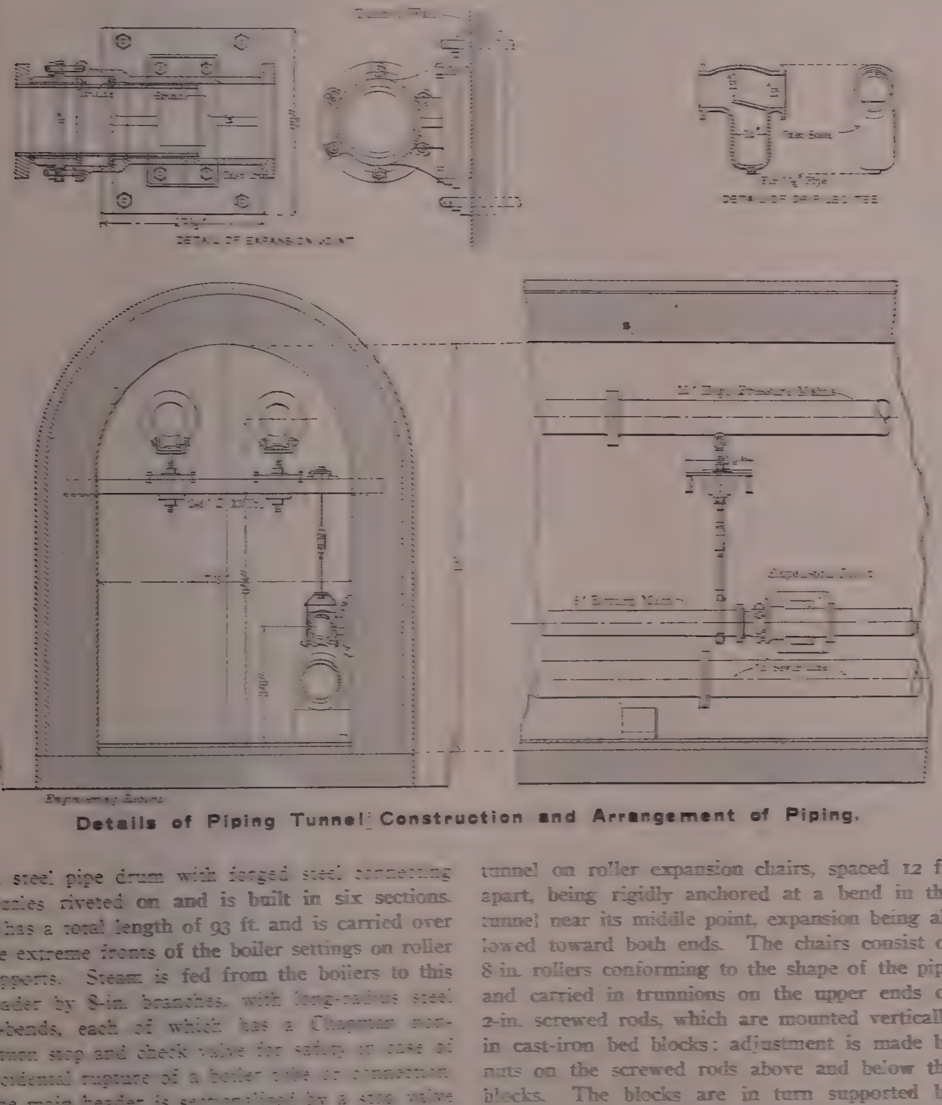


Details of the Receiving Equipment and Coal and Ash Handling Apparatus ning reheater and purifier, and thence through a Worthington hot-water meter for measurement. There are two Gunning reheaters and purifiers installed, each of 1,200 h.-p. capacity and capable of raising the temperature of the feed water to 310° Fahr., at the same time purifying it. They are 40-in. steel tanks, 15 ft. in length, and are fitted with 800 ft. of 1¼-in. copper tubing. The filters are cast-iron tanks 75 in. in diameter by 8½ ft. high, designed to withstand a pressure of 150 lb. They have manholes and handholes for convenience in cleaning, and have by-pass connections if desired. This equipment of reheaters and filters was supplied by the Duquesne Manufacturing Co., Pittsburg, Pa.

Steam Piping.—The steam piping system is unusually extensive, owing to both the size of the plant and the distance between the boilers and the steam-using machinery. There are a main and an auxiliary header in the boiler house, a distributing header in the engine room pipe cellar, some 500 ft. distant, and two 12-in. supply mains, each containing about 600 ft. of pipe, connecting the two. The main boiler-house header is a 16-in. steel pipe drum with forged steel connecting nozzles riveted on and is built in six sections. It has a total length of 93 ft. and is carried over the extreme fronts of the boiler settings on roller supports. Steam is fed from the boilers to this header by 8-in. branches, with long-radius steel U-bends, each of which has a Chapman non-return stop and check valve for safety in case of accidental rupture of a boiler tube or connection. The main header is sectionalized by a stop valve in the middle, each half having connections to four boilers and one of the delivery lines leading to the engine room, thus enabling the service to be maintained in case of disablement of either delivery line or section of the header. For further protection, the two delivery mains are interconnected at a point near the main header by a 12-in. tie line, which is so valved that either half of the main header may deliver steam to either one of the delivery mains independent of the other. Steam is supplied to the pumps, stoker engine and auxiliary equipment at the boiler house by a 6-in. auxiliary main spanning the firing floor transversely at the middle, which has a connection to the main header on either side of the sectionalizing valve. It drops at the outer wall into the basement, where 2-in. branches are taken off to supply the two feed pumps and the two reheaters and purifiers, and a 1½-in. branch to the drip pump.

The two supply mains, which are carried through the tunnel to deliver steam to the engine room in the main building, connect through electrically-operated stop valves with main boiler-house header at the middle point of either half section, and extend thence horizontally to the rear, connecting through long-radius bends and return loops to drip pockets underneath the tunnel entrance platform. From here the lines rise vertically 15½ ft. and enter the tunnel through 6-ft. radius bends. The electric valves are 12-in. Chapman gate valves with electric motors operated from the engine room, by means of which instantaneous control of the steam supply is possible; the motors are mounted on the valve yokes and drive the yoke nuts through double gearing, which may, however, be detached for hand operation of the valve. The mains are carried in the tunnel on roller expansion chairs, spaced 12 ft. apart, being rigidly anchored at a bend in the tunnel near its middle point, expansion being allowed toward both ends. The chairs consist of 8-in. rollers conforming to the shape of the pipe and carried in trunnions on the upper ends of 2-in. screwed rods, which are mounted vertically in cast-iron bed blocks; adjustment is made by nuts on the screwed rods above and below the blocks. The blocks are in turn supported by pairs of transverse 6-in., 13-lb. channels 24 in. apart, bedded in the tunnel masonry at 12 ft. intervals. Expansion from the anchorage toward the engine-room end is provided for by 20-ft. U-loops extending horizontally at right angles to the mains, near the ceiling line, the engine-room ends of which are firmly anchored by lugs of fittings to a 10-in. 25-lb. channel attached horizontally to the steelwork of the building. The arrangement of the engine-room mains will be referred to in a succeeding article.

The tunnel mains are graded with the flow of the steam and each has a drip leg at the base of the riser from the boiler house to the tunnel, another at the bend near the middle of the tunnel, and a third at the free end of the expansion loops in the engine room. The last legs are connected to the engine-room drip system and the two others to a drip system in the boiler house. The legs at the ends of the lines are open drip pockets of usual construction, but those at the mid-tunnel points are of a novel separator type, indicated in an accompanying detail drawing. The boiler-house header is drained by four 1-in. drip connections in either half, which deliver into 1½-in. drip mains underneath. These drip mains are joined by two 1¼-in. lines from the drip legs at the boiler-house end of the tunnel mains and a 1½-in. line from the mid-tunnel drip legs, and are carried down into the basement as a 2½-in. main to the receiver of the drip pump. This receiver has 2-in. drip connections from each of the reheaters and a 1¼-in. connection from the auxiliary steam header in the basement. The condensation accumulating in the receiver is automatically delivered by the 7½x4½x6-in. Wilson-Snyder duplex drip pump through a 3-in. connection to the boiler feed main in the basement. All drips which are liable to be impure, such as those from exhaust heads, hot water heaters, pumps, and exhaust piping, will lead directly to the blow-off tank.



Details of Piping Tunnel Construction and Arrangement of Piping.

Feed and Blow-off Piping.—The feed-water piping is also of unusual arrangement owing to the location of the feed heaters in the engine room, over 500 ft. from the feed pumps. They were located there for convenience of connection to the exhaust steam system and also to the return systems collecting condensation from the heating systems and steam lines. The heaters form the reservoirs of feed supply for the boiler, make-up being added from the city mains automatically by a float valve as required. The heated feed water is thence delivered to the feed pumps in the boiler house by a line of 8-in. extra-strong wrought-iron pipe, which is carried through the tunnel, dropping in the boiler house to the basement. It is fitted with flanged joints and suspended in the tunnel by flexible hangers from the cross supports for the steam mains, the hangers being a simple type of stirrup carrying a roller block for the pipe, adjustment of height being secured by a turnbuckle support. Expansion is provided for in this line by three slip expansion joints, one at either end of the tunnel and one near the middle.

The feed-water main, at the boiler-house end of the tunnel, drops vertically to the basement, where it is carried across, connecting first to a surface condenser, with by-pass connections, and thence to a special air chamber at the pump suction, from which 6-in. branches lead to each feed pump. In this condenser the exhaust steam from all pumps and steam-using machinery in the boiler house is condensed to prevent its escape from the exhaust head above the roof. The air chamber consists of a section of 12-in. wrought-iron pipe and fittings, standing 10 ft. high, into which the feed water is delivered at the bottom and from which the pump suction is taken off through a cross fitting, 3½ ft. above the floor; the 6-ft. section of pipe above this is capped with a blank flange and forms the air chamber.

The feed pumps deliver through a common 5-in. copper main which connects first into the reheater and purifiers, thence to the filters, and through the water meter to the feed main, a 5-in. copper line on the basement ceiling, extended longitudinally underneath the boiler fronts. In the discharge connection from the pumps, both the reheaters and filters are by-passed to permit of direct delivery to the boilers if necessary. From the 5-in. feed main 2-in. brass pipes are carried up through the floor, one at the side of each boiler. The branches deliver to the boilers through a graduating valve about 4 ft. above the floor and thence through combination check and stop valves at each of the boiler connections.

The blow-off system consists of a main 4-in. line in the basement at the rear of the boilers to which two 2½-in. connections are made from each boiler. The boiler blow-off connections lead from opposite ends of the mud drums and are each fitted with two gate valves in a series to insure freedom from leakage. Where the blow-off connections lead through the interior of the setting to the rear wall, they are covered with terra-cotta pipe to prevent burning the pipe. The 4-in. blow-off line leads to a tank at the rear of the basement into which the hot discharge as well as the dirty drips are delivered for cooling before running to the sewer. This blow-off tank is of ½-in. steel plate, 4 ft. in diameter by 12 ft. long, and is heavily braced to withstand pressure. It has a 4-in. vapor connection leading to an exhaust head above the roof to discharge steam and vapor, and it has a cooling coil to insure the delivery of the blow-off discharge at a temperature low enough to avoid injury to the sewer. The cooling coil consists of ten loops of 2-in. brass piping, containing in all 238 ft. of pipe, which is fitted between two bronze manifold headers, having 3-in. connections to the water service for the hot water supply of the building. The blow-off tank has an over-flow to the sewer at a point 8 in. from the top of the tank, so that the latter is kept filled with water continuously, which serves to reduce the temperature of the blow-off discharge as it is received.

The Tunnel.—The tunnel, which has a width of 7½ ft. and a height to the crown of the arched roof of 12 ft., has a length of 300 ft. from the boiler house to the end of the pipe cellar, underneath the engine room. It enters the main building at the pipe cellar level, 12 ft. below the engine-room floor and 41 ft. below that of the main library floor, and extends from the latter section southward 150 ft. to the south wall of the museum division. There it bends at an angle of about 35 deg. to the eastward and thence continues 150 ft. farther to the power house. The tunnel has a total length of 410 ft. from the engine room to the boiler-house wall and enters the latter 32 ft. above the boiler-room floor, as previously stated. At a point about 60 ft. from the boiler house it emerges through the slope of the side of the ravine and is carried thence to the boiler house above ground, being carried across the last 30 ft., where the ground drops precipitously, by a heavy concrete arch. The tunnel is of concrete construction with side walls and arch 22½ in. thick, consisting of 18-in. inner walls, a course of waterproofing and a 4-in. outer wall.

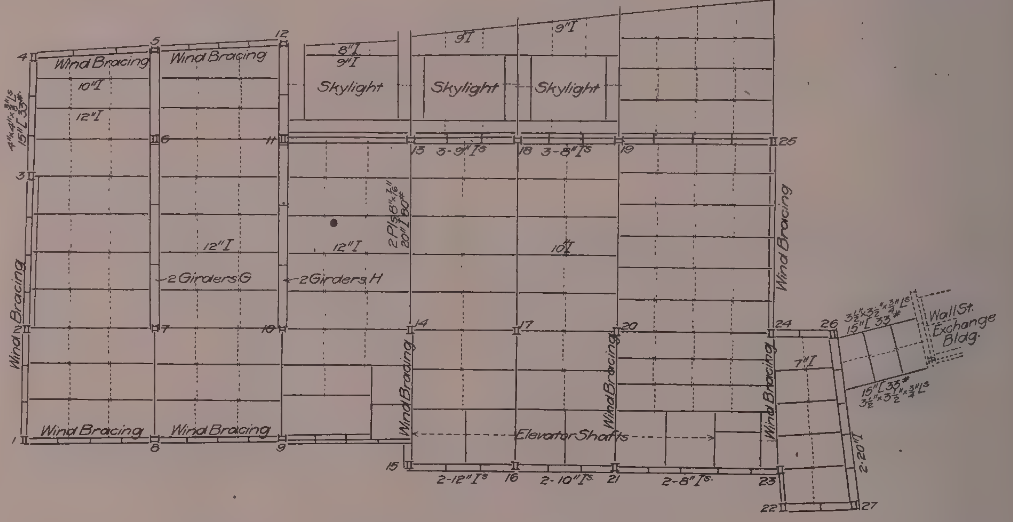
The entire steam generating equipment and auxiliaries and the systems of piping were designed by Baker, Smith & Co., New York, and installed by their Pittsburg branch. The coal and ash handling equipment was installed by John A. Mead & Co., New York. The architects of the building were Alden & Harlow.

(To be Continued.)

Magnetization of Diamond Drill Rods used in a basic hornblende-chlorite schist enclosed on either side by more acid rocks, is described by Mr. D. W. Johnson in "Science." The rods became strongly magnetic and would sustain heavy spikes. The phenomenon was attributed by some engineers to the influence of nearby ore bodies or the proximity of large deposits of magnetite. The holes where the magnetic effects were noted were inclined toward the north several degrees from the vertical, and conditions were therefore especially favorable for the production of strong magnetic currents in the drill rods. It is well known that an iron bar held in a north and south direction is more readily magnetized than when held in an east and west line.

The Trust Company of America Building. —IV.

Steel Superstructure.—The steel cage superstructure 330 ft. high above the curb has twenty-five stories and is made with twenty-seven main columns arranged, as shown in the floor plan, in seven transverse rows of three columns each and one group of three columns in the wing extending from one corner to provide a connection at every floor with the Wall Street Exchange Building, and thus give the latter an entrance from Wall St. The columns are all of closed rectangular construction made up with channels and plates shop-riveted in two-story lengths from 25 to 40 ft. long over all and spliced about 17 in. above the floor lines with pairs of cover plates shop-riveted to the lower sections of the columns to form jaws receiving the upper sections. At column splices horizontal diaphragm plates are inserted in the joint to distribute the pressure, as shown in the detail sketch.



Third Floor Beam Plan.

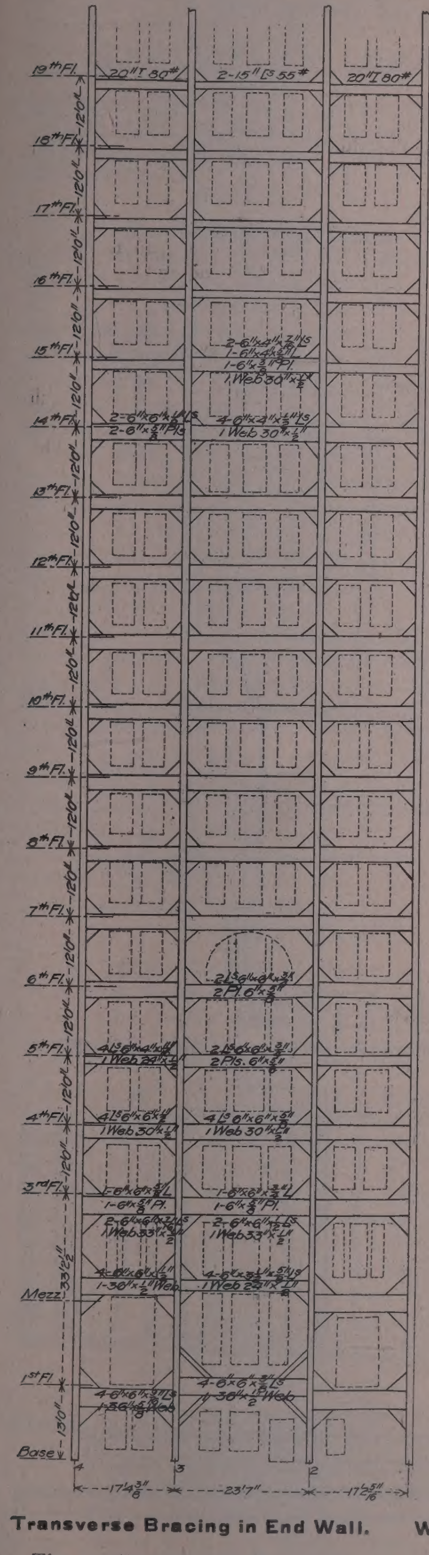
The construction of the column is extremely simple, all girders and beams being seated on reinforced horizontal bracket angles and having their webs field-riveted to the columns when necessary. The upper sections of the columns are made with two channels, latticed where the loads are the lightest and elsewhere having two cover plates making closed sections. As the stresses in the columns increase downwards, the sections are increased by increasing the sizes of the channels and the number and thickness of cover plates, and in the lower stories, where the loads attain a maximum of 2,310,000 lb., a cross-section of 172 sq. in. is provided for column 12 by adding an interior pair of channels back to back with a web-reinforcement plate between. In other cases, as in column 17, the basement section is reinforced by pairs of 14x13/16-in. plates riveted to the webs of the 15-in., 55-lb. channels. Vertical connection plates for the wind bracing are shop riveted between pairs of 6x4-in. and 4x3-in. angles shop riveted to the cover plates of the column, and have open holes for the field rivets of the diagonal braces.

The location of columns and the general spacing and arrangement of floorbeams and girders is shown in the third-floor plan which, however, is special on account of the two plate girders *G*, and the skylights at the foot of the light court between columns 11 and 19, which do not appear in other plans, and on account of the omission of bay window framing which occurs in the upper stories between columns 11 and 25. The floorbeams are uniformly 10-in. and 12-in. longitudinal I-beams spaced from 4½ to 6 ft. apart and carried generally by the 20-in. transverse ple arrangement for different tiers and facilitates I-beam girders. This gives a regular and sim- shop work and erection. The wall is carried at each story by 10-in., 12-in. and 15-in. I-beams in the side and rear, which support the brickwork independently of the floors. In the Wall St. front, the wall girders are slightly varied to correspond with the requirements of the heavier stone masonry.

In order to afford a wide unobstructed area in the banking room, two stories high, which extends to the third floor, the second and third story sections of columns 6 and 11 were omitted and the twenty-two upper stories of those columns are carried on heavy plate girders *G* and *H* about 43 ft. long, which span the banking room and are carried at one end by the wall columns and at the other end by interior columns about 17 ft. from the opposite wall. Each of these girders is made in two separate duplicate halves, each a complete plate girder with an 85x½-in. web plate, four 8x8x1-in. full length flange angles, and six 18x¾-in. flange cover plates from about 16 ft. to 32 ft. in length. The girders are spaced far enough apart so that the webs engage the opposite faces of the columns supporting them and are field connected to them with forty-two ⅞-in. turned bolts in each, the inside flanges being cut to clear the column. The girders will be shipped and erected separately and afterwards wil be connected by three vertical transverse diaphragms, field assembled, with bolts put in position through hand holes left for that purpose in the webs.

The intermediate columns are seated on the top flanges of the girders about 13 ft. from one end. This loading greatly increases the shear in the girder webs which are accordingly reinforced by pairs of 83x⅜-in. plates about 16 ft. long riveted over the vertical legs of the main flanges angles and also riveted through vertical filler strips about 12 in. apart. On the center line of the intermediate column, eighteen vertical web stiffener angles are riveted to the girder as close together as possible to provide against buckling under a load of about 671 tons which is received at that point. The pair of girders 5-7, are proportioned for a maximum movement of 12,460,000 ft.-lb. and together weigh about 30 tons.

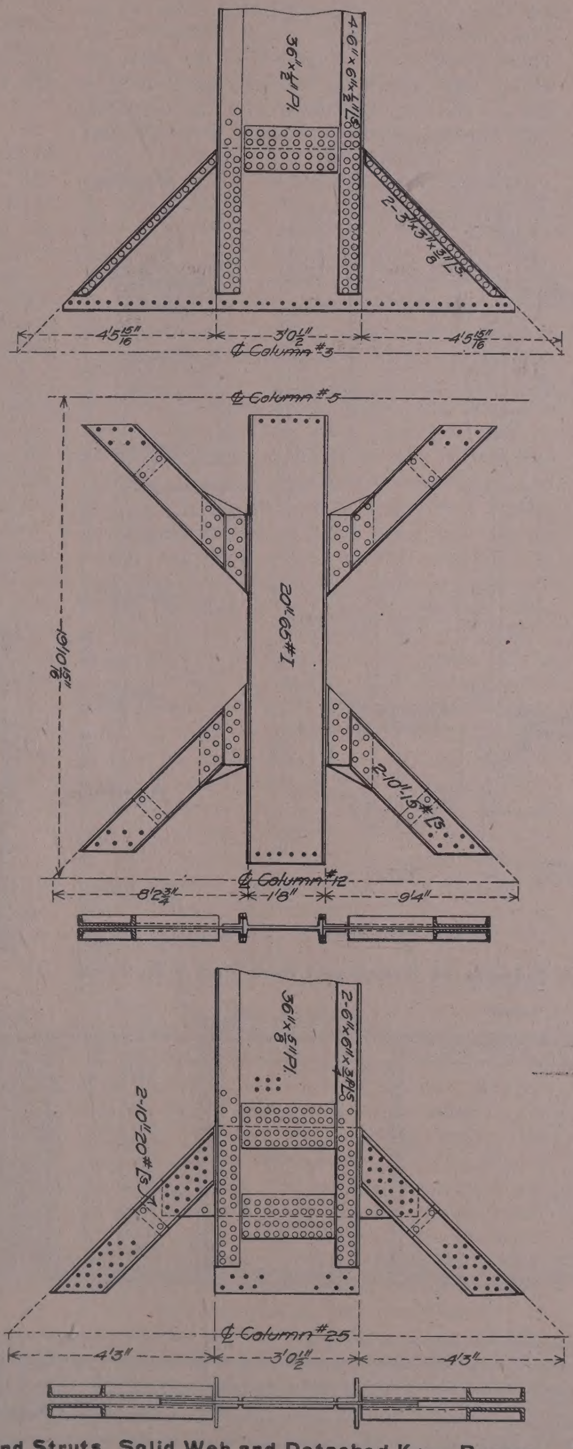
In the upper stories the bay windows occupy the full widths of the panels from 15 ft. 4 in. to 16 ft. 4 in. long and project about 4 ft. beyond the faces of the wall. Here there is a regular 10-in. or 12-in. I-beam concentric with the columns to carry the floor, and a duplicate I-beam bracketed out from it to carry the wall masonry independently beyond the column faces. The bay window framing is carried beyond these pairs of wall beams by transverse 10-in. I-beams cantilevered across them and anchored at the inner ends to the regular 10-in. I-beams in the main floor.



Transverse Bracing in End Wall.

The cantilever beams have their top and bottom flanges flush with those of the wall girders and are cut to clear them. They are web-connected at the points of intersection, and the cantilever stresses are provided for and the beams made continuous across the 10-in. space between the wall girders by means of cast-iron separators in the lines of the cantilevers and 6x¾-in. top and bottom splice plates field riveted to the flanges of both portions of the beam. Each window has a pair of cantilever beams 6 ft. 2 in. apart. Their outer ends are connected by an 8-in. fascia channel continued obliquely to the ends of the wall girders and carrying at the angles pairs of vertical T's made with two angles riveted together back to back.

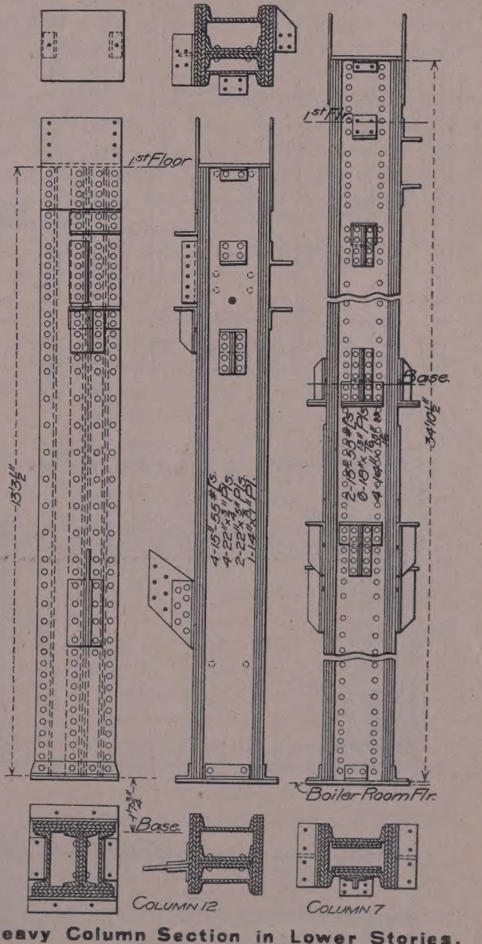
The superstructure is proportioned for a horizontal load produced by an assumed wind pressure of 30 lb. per square foot on the exposed surface of the building. This pressure taken in a direction perpendicular to Wall St., is distributed throughout the full depth of the building, about 130 ft., and, being resisted by the walls and by the deep floorbeams and rigid connections, does not require the provision of special bracing except in the planes of the walls, where it is distributed through several columns. In the direction at right angles to this the maximum width of the building is only about 61 ft. and as the structure is exposed above the sixth story, it was necessary to provide special systems of transverse bracing. These are accordingly furnished in each of the five rows of columns so marked in the floor plan. The details and dimensions of the bracing vary in different panels, but it all consists of either solid-web or detached knee braces, increasing in cross-section in the lower stories and arranged throughout to conform with architectural requirements and not cause interference with the window openings.



Wind Struts, Solid Web and Detached Knee Braces.

In the Wall St. front, the wall girders are pairs of 15-in., 55-lb. channels in the middle panel and single 20-in I-beams in the side panels down to the fifteenth floor. Their connections with the columns are made with solid-web knee-braces. At the fifteenth floor, the center panel girder is a 30-in. plate girder with a ½-in. web and four 6x4x7/16-in. angles. Similar girders are used in the center panel down to the seventh floor inclusive, but vary by the increasing thicknesses of the flange angles which reach a maximum of ⅝ in.

In the sixth and seventh floors, the girders are made 27 in. deep to give the minimum obstruction where they cross the large arch windows. They have two 6x6x¾-in. flange angles and two 6x⅝-in. flange plates. In the fourth, third and mezzanine stories, the corresponding girders have varying dimensions, the deepest being at the third floor, where it has a 33½-in. web. In the panels on both sides of the center, the wall girders from the fourteenth story downwards are all plate girders with webs 30 in. deep except in the lower stories where they vary from 24 to 36 in., according to the architectural requirements. The flange angles are 6 x 4 x ½ in. and 6 x 6 x ½ and ⅝ in., thus making very rigid members to carry the masonry and receive the horizontal stresses.



Heavy Column Section in Lower Stories.

In the side walls, longitudinal bracing was found necessary below the tenth floor between columns 1-9 and 4-12 and is made with four long knee-braces in each panel intersecting in the middles of the columns and wall girders so as to make inscribed rectangles in the higher stories, and inscribed hexagons in the upper stories, and in all cases relieve the columns from bending moments. The knee-braces increase in section from the tops downwards, from pairs of 9-in., 15-lb. channels. At the rear of the building, the wind bracing is made with plate girders and channel knee-braces and combinations of channel and solid web knee-braces corresponding in the upper stories to the panels shown for the lower stories and extending only to the nineteenth floor.

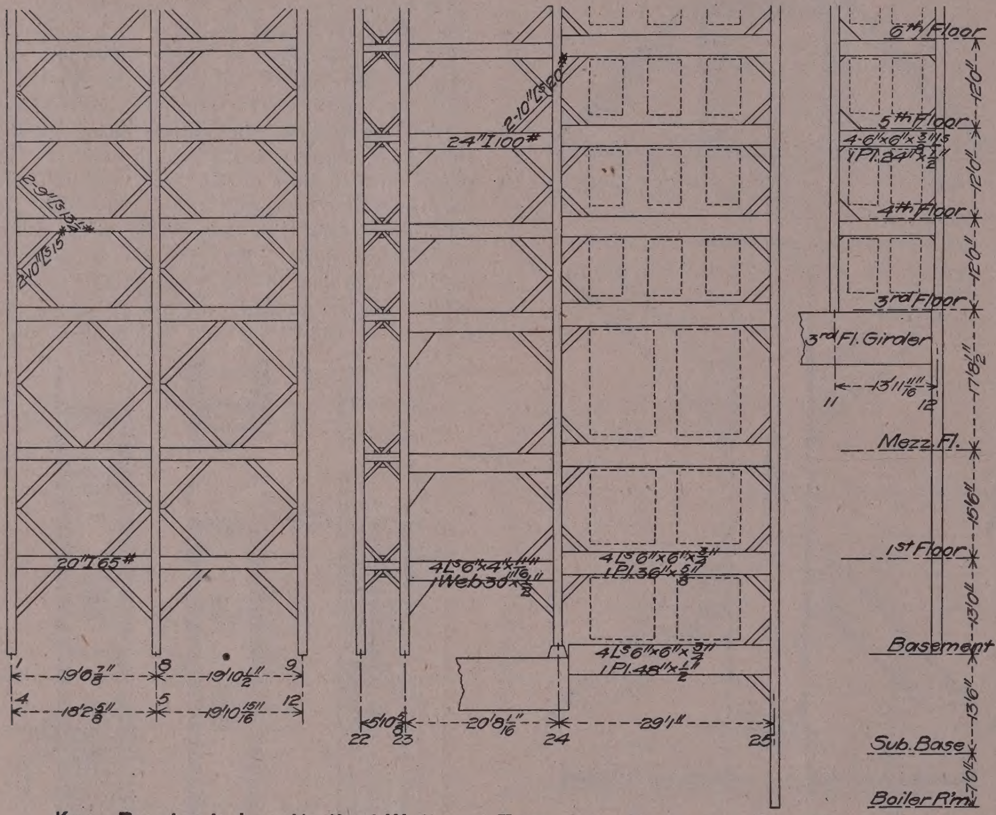
Care was taken to design the connections for both solid-web and detached knee-braces so as to concentrate the work as much as possible in the shops and make the assembling simple, with the fewest practical number of field-driven rivets. The solid-web knee-braces constitute special end sections of the girder webs, shop spliced in position, are shipped complete without danger of misplacement, and are assembled to the columns with field-driven rivets through their vertical flanges. In case of detached braces made of pairs of channels, a special section of web is shop spliced to the girder with projections beyond the top and bottom flange angles to receive the knee-brace channels shop-riveted to them on both sides. The web connections at the ends of the girders and at the extremities of the knee-braces are field-riveted to the columns as in the other cases.

In the short panels between columns 22 and 23, the horizontal girders and the knee-braces which intersect them are all riveted up complete in the shops and form X-shaped members, shipped whole and easily assembled. In other cases the detachable knee-braces are field-riveted to the I-beam girders through pairs of horizontal connection angles shop riveted to web plates between the backs of the knee-braced channels.

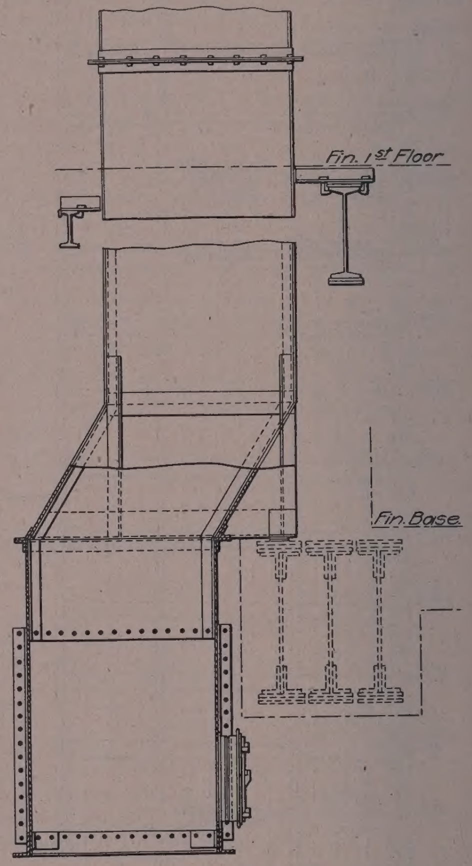
The steel smoke flue, 360 ft. high, is composed of two-story lengths of a rectangular cross-section spliced 2 ft. above floor levels in alternate stories by outside horizontal flange joints. The thickness of metal increases from ¼ in. at the top to 7/16 in. at the bottom, and the stack is braced by horizontal struts in the center of each side at every alternate floor. These struts are not connected to the stack, but merely abut against its vertical faces, leaving it free to move up and down with the expansion and contraction due to changes in temperature. The struts consist of single 3x3-in. angles fastened to the tops of the floorbeams by hook bolts. The base of the stack has a rectangular shoulder giving it bearing on one of the triple web girders in the basement floor and providing for an offset which allows the flue to clear the girder and extend below it to connect with the boilers. The bottom part of the flue is thus virtually suspended from the sub-structure girders as shown in the diagram.

The total weight of the structural steel work in this building is about 3,400 tons. Mr. Francis H. Kimball is the architect, Messrs. Purdy & Henderson the consulting engineers, and the George A. Fuller Co. is the general contractor. The Carnegie Steel Co. is the contractor for the structural steel work, which is erected by the Fuller Co.

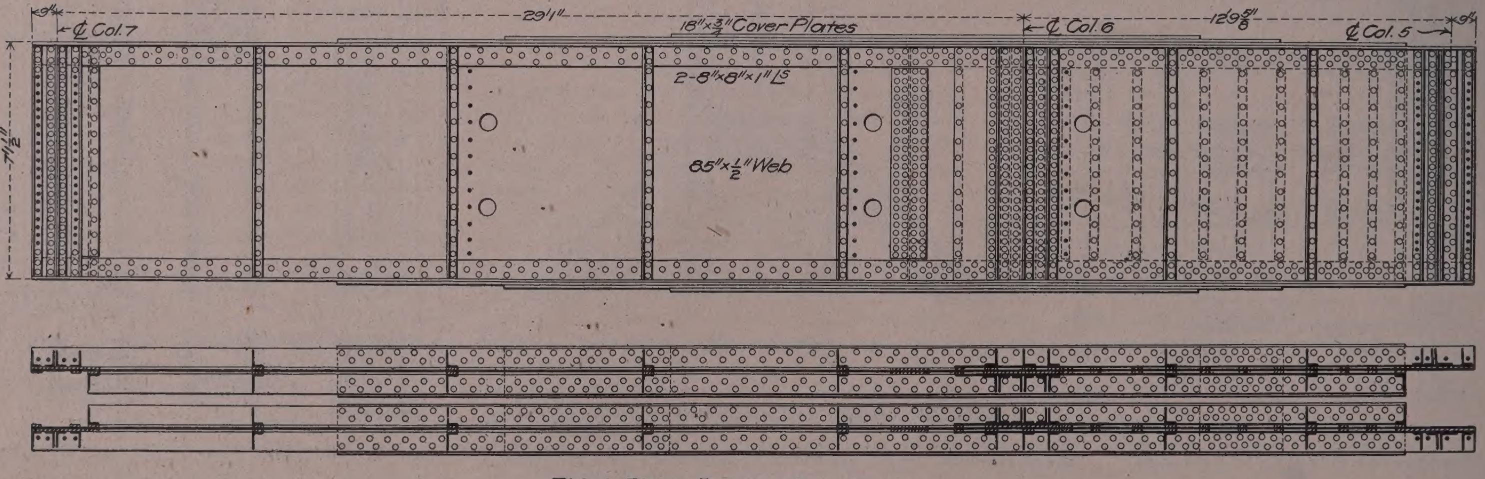
The National Fireproofing Co. furnished the hollow tile for the floor arches, partitions and columns and girder protection.



Knee Bracing in Longitudinal Wall and Transverse Bracing at Rear End of Building.



Support of Foot of Smoke Stack.



Third Floor Double-Web Girder.

Trackless Trolley Lines in Italy.

Trackless trolley lines are being introduced in Italy by the Electric Traction Co. of Milan, which has in operation one line between Spezia and Portovere, a distance of about 2.3 miles, and is building two other similar lines. The vehicles used resemble omnibuses, each seating 14 persons and weighing when empty about 3,300 lb. Two 4-h.-p. motors geared to the rear wheels propel it. The trolley wires are suspended either on span wires or brackets, about 18 ft. above the road. Two wires placed side by side about 14 in. apart are used and carry a 500-volt direct current. The cars operate satisfactorily over grades as steep as 6.8 per cent. and around curves of 25 ft. radius. Two cars run from 6 a. m. to 8 p. m., and each makes about twenty round trips per day. The power consumption averages about 320 watt-hours per car-mile.

Book Notes.

A new edition of Prof. M. S. Ketchum's "Design of Steel Mill Buildings" has been brought out at $4 by the Engineering News Publishing Co., New York. As the first edition was fully reviewed in this journal when it appeared, it is only necessary to say that its many valuable features are retained in the new edition, which contains about 100 pages of new material and illustrations of the same high character as the older portions.

It is a pleasure to mention the appearance of such a good book as Dr. Sanford A. Moss's "Elements of Gas Engine Design," which is the latest addition to Van Nostrand's Science Series. In clear and compact form it presents the essence of a subject which interests a wide circle of readers, from the managers of industrial establishments to the amateur runners of motor-cars and boats. The book is neither overloaded with pedantic theory and useless formulas, nor is it "written down" to the assumed intellectual level of those who have never advanced beyond a catechism. It begins with an explanation of the chemical and physical phenomena on which the operation of an internal combustion engine depends, and thus prepares the way for a consideration of gas engine fuels and their relative values. Several chapters are then given to an explanation of the action that takes place in a cylinder of one of these engines, so that the reader is prepared to understand the method of determining the size of cylinder for a given power. Afterward the methods of governing such motors, the cylinder action in two-cycle engines, the details of design and the leading formulas and constants used in determining the parts of an internal combustion engine are taken up in turn. (New York: D. Van Nostrand Co., 50 cents.)

There are few branches of engineering which are so little studied by most engineers as geodesy, in fact some leading American geodetic specialists consider themselves astronomers rather than engineers. The field work they do, unlike most engineering branches, leaves no permanent record save a few monuments, while the mathematical portions of the work are of a character wholly foreign and practically unknown to other engineering work. Nevertheless there are some features of it which are very interesting to anyone with a liking for mathematics, and a very good account of them will be found in the second edition of Prof. T. W. Wright's "Adjustment of Observations by the Method of Least Squares, with Applications to Geodetic Work." In its new form this standard treatise is in a considerable degree the work of Mr. J. F. Hayford, chief of the computing division and inspector of geodetic work, U. S. Coast and Geodetic Survey, and its value is materially enhanced by the admirable practical applications and suggestions contributed by this colaborater. The most important feature of the volume is its very definite explanation of the necessity of accuracy in measurements which are to be adjusted by the method of least squares. There is a somewhat common belief that any set of observations, no matter how inaccurate, can be ironed out into a smooth form under the pressure of this mathematical instrument. This is, of course, wholly incorrect, for there is no remedy for the inaccuracy of the observer, and all that the method of least squares can do is to substitute for a straight-out guess one which is guided by a knowledge of the theory of probable errors. Nobody can read this book without recognizing this fact, for it is emphasized in many places. Special attention should be called to the ninth chapter, where the principle of least squares is used to select methods of making observations so as to secure increased accuracy or equal accuracy with fewer observations. The book, in its revised form, will unquestionably retain its place as the standard American work on the subject. (New York, D. Van Nostrand Co.)

After the recent publication of so many books on steam turbines, it requires considerable nerve to bring out another right away unless the subject can be approached from a new point of view. Fortunately Messrs. T. Stevens and H. M. Hobart have had a novel aim in the preparation of their "Steam Turbine Engineering," and they have followed it with praiseworthy consistency, in spite of the great amount of labor in doing so. The result of their work is a book that everybody will need who is interested in the steam turbine as a prime mover rather than a piece of laboratory apparatus, whose operations are to be enveloped in a haze of deep theory and high mathematics. The subject is discussed from the standpoint of the purchaser or user, only incidentally interested in the theory and design of the machine, but very much concerned with its first cost, steam consumption and maintenance charges. It is the latter data he requires to compare the turbine with the reciprocating engine, and not the former, and it is these data that the authors supply in a form readily consulted. In the introductory chapter information is given concerning the cost of turbines and complete power plants. In the next chapter, there is a useful explanation of the meaning and relations of the various British and metric units used in steam engineering, with tables for transforming quantities from one to the other. Then follow ten chapters on the de Laval, Parsons, Curtis, Rateau, Zoelly, Riedler-Stumpf, A. E. G., Hamilton, Holzwarth, Elektra and Union types. The general character of the information in each chapter can be shown by mentioning the discussion of the de Laval machine. After a brief historical statement to show the importance of the diverging nozzle introduced by de Laval, the authors take up in turn the relative speed of steam and turbine, the total efficiency of conversion of energy in steam, the efficiency of the electric generators used in the calculations of turbine efficiencies, the effect of varying the pressure at full load, the effect of varying the vacuum at full load, the same data for other loads, the internal losses in the turbine, and the main features of its design. The great value of the data as to steam consumption lies in their being derived from experiment and not from theory, thus making them far more useful to the purchaser of equipment than the information usually given. After taking up in this way the machines named, the authors give a chapter on the properties of steam and another on the calorific value of fuels. The next two chapters are on the steam economy shown by tests of reciprocating engines and turbines, the figures given being considered by the authors to be representative of the performance of the various types of machines. Chapter seventeen is on the steam pressure, superheat and vacuum in a number of turbine plants, the next chapter is on condensers used in different stations, chapter nineteen gives similar information regarding foundations, chapter twenty gives areas, volumes, plans and pictures of a large number of recent power stations, and the next chapter is a table of the boiler heating surface, grate area, superheater surface and economizer surface in numerous stations. The twenty-second chapter is one of the best pieces of compilation ever carried through in an engineering book. It is a digest, in parallel columns, of the essential details of a number of the latest turbine plants, and will be found particularly valuable to designers of such stations. The following chapter is a detailed discussion of what has been done with marine steam turbines, and then comes a fairly complete bibliography. The volume closes with a collection of excellent power tables and a good index. It will be found useful by everybody who wishes to know what experience has shown that steam turbines can do and the cost of doing it. (New York, The Macmillan Co., $6.50.)

Letters to the Editor.

CRACKING OF CONCRETE ARCHES.

SIR: In your editorial on the first page of your issue of Oct. 13th on "The Cracking of Reinforced and Plain Concrete Arches," it seems to me you leave out several important considerations, which it would be well to notice in estimating the serious effects of cracks. These are:

(1) The effect of cracks in admitting water by capillary attraction to rust the metal reinforcement. It is claimed concrete is a good preservative of steel. What will be the result when the concrete is cracked?

(2) In bridge abutments and piers, what will be the effect of the hammering action of trains, when the concrete is cracked?

(3) In comparing cracked concrete with cracked masonry you do not note the comparative facility with which the mortar joints of ashlar masonry may be dug out and repointed.

(4) In comparing concrete with masonry as to the tendency to crack, is there any authority for the belief, or any reason to suppose that first-class stone masonry laid in cement mortar, properly designed and with good foundations, will ever crack from expansion?

(5) Will first-class masonry crack under any normal conditions of service?

Yours truly, C. P. HOWARD.

[Mr. Howard has raised some interesting questions in connection with the subject of the cracking of concrete. As stated in the editorial to which he makes reference, it is a little difficult to realize why the cracking of concrete is so very different in its general results from the cracking of any other masonry. Obviously the general treatment of cracked concrete, like the cracking of other masonry, must depend largely upon the experience of the engineer in charge of the work, as such treatment will depend much upon local conditions.

If a crack were left open in reinforced concrete undoubtedly water might enter, and if the crack were deep enough the water would corrode the steel reinforcement, but an engineer would be negligent to permit such a crack to remain open. He would naturally cut it out if necessary and fill it under such conditions that it would not again open, and thus give the steel reinforcement complete protection.

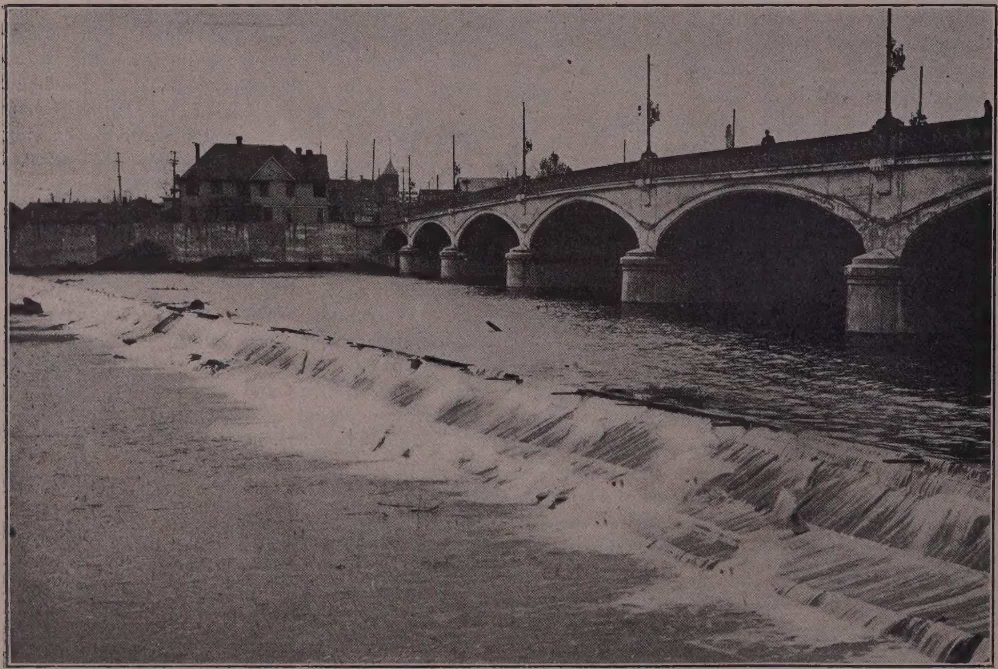
If a crack occurred in either plain or reinforced concrete or in ordinary masonry under such circumstances that passing trains would produce angular or rocking motion it is highly probable that in time injury, perhaps serious, to the mass would ensue. The obvious remedy, however, in any such case is that stated above, viz., fill the crack so that no motion could take place. It is possible that the joints of stone masonry may be cleaned out and repointed with a little more facility than the cracks in plain or reinforced concrete can be filled, but the difference is not enough to be of any practical consequence.

Mr. Howard's question 4 seems a little strange in view of the many cracks due to varying temperature which occur in first-class stone masonry laid in Portland cement mortar. Such cracks are not uncommon in long masses of masonry, even with the most satisfactory foundations, and an interesting example has been afforded by the opening of joints in some of the masonry arches of the Sudbury aqueduct.

His question 5 is a little difficult to answer specifically on account of its generality. It is clear that first-class masonry should not crack in consequence of the stresses developed by conditions of service for which it is designed, but obviously it may crack under such service, in consequence of abnormally varying temperature or the yielding of foundations. Wherever it is worth while, there seems to be no reason why cracks in any class of masonry whatever, including reinforced concrete, should not be promptly filled and under such conditions of temperature and use as will in general prevent further opening.]

ENGINEERS IN PUBLIC LIFE.

SIR: May I venture the following lay reflections upon President Humphreys' thoroughly refreshing remarks at the University of Pennsylvania? I have come in close enough contact with engineers to feel the unique possibility that is theirs for encouragement of general sanity along the lines President Humphreys so clearly indicates. By training and by temperament the engineer is usually better fitted than either the mere commercialist or the mere professional man to comprehend that the social and industrial millennium lies neither at the egoistic nor the altruistic pole, but at an unstable point between, which can be determined, not by governmental regulation, not by public sentiment, but only by an almost untrammelled play of that curious compound of idealism and expediency known as individual good-will. To the idealist's soreness against the sound, archaic dictum, "Business is business," the engineer should be able (as the commercialist is not) to apply the balm of the consideration that although there is no room for sentiment in business, yet business is but one department of life, and happily the remaining wide field of individual conduct is not only open to the cultivation of the altruistic instincts, but is, in point of easily observed fact, more and more given over to that cultivation. A careful analysis of this balm would of course disclose, among other interesting things, the fact that jurisprudence still glories in her innocence of definite aim and still jumbles the moral and the expediential meanings of "justice" to the almost unshakable advantage of the agitator, the demagogue, the newspaper and the politician, who seems often to have persuaded himself that his strong predispositions have really taken on the authority of "principles." The scientific training of the engineer analyzer should make him susceptible to the conclusion that law is not an affair of principle, still less of "justice," but is, up to the point where social order is maintained, merely an arbitrary, indispensable necessity. Welfare judgments, being naturally and properly individual, the search of popular government for "general (?) welfare" has been the hunting of the snark—and it is time we were opening our eyes. But will the engineer so see and so say? The editorial columns of most of your leading contemporary engineering journals show from time to time the conventional blind faith in the possibility of a progressive humanism governmentally conducted. The obvious truth that the humanism enterprise is essentially self-conductive the editors would hardly admit; and that governmental "regulation" in the interest of "welfare" does not and cannot regulate, but can only impede and divert temporarily the natural growth of good will, this they are far from acknowledging. A political economy that bases on "ethics," i. e., on a class judgment as to what ought to be, is not a promising means to President Humphreys' crying end, and so I would ask: Are engineers, as a class, likely to avoid the pitfall of ethico-political economy while their technical press for the most part flounders therein? If engineers will not take the pains to observe this pitfall then surely the comparative silence on political and economic questions which they have had the grace to maintain might well remain unbroken. M.

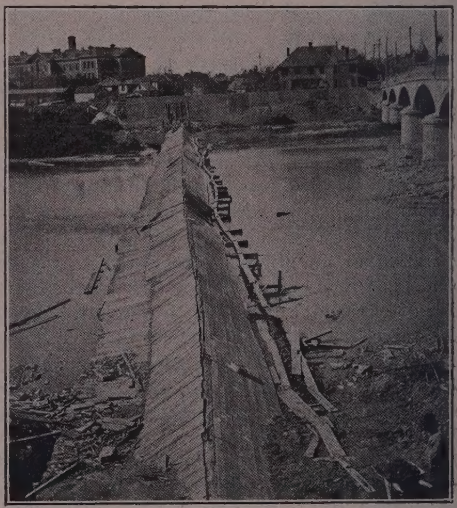


View Showing Water Flowing Over Completed Dam at Dayton, Ohio.

A TEMPORARY DAM.

SIR: The Miami River in its course through the city of Dayton, Ohio, is a very shallow stream during the dry season, and its bed is covered with a rank growth of weeds and willows, offensive to health and sight. There has been talk of damming the river, but objections were raised by property owners who would be affected by the rise in the water. After much discussion it was finally decided that the city should build a temporary dam on the site of an abandoned temporary bridge which had been used during the construction of a concrete bridge. To cover the expense, the council appropriated the sum of $2,000, and the job was let by contract for $1,500. The old bridge was a timber structure resting on piles driven into the river bottom. These passed through a layer of gravel and penetrated a layer of hard pan beneath.

The method of procedure adopted by the contractor was this: He first cut off the piles near the river bottom and used them as an anchorage for the dam structure. The dam was then built on top of these. A row of sheet piling was driven by hand on the upper side of the dam, and these were driven to a depth of only two or three feet in some places. The dam was entirely covered with tin and matched flooring on top of this to make it water tight. Then straw was sunk along the upper edge of the dam and covered with a layer of earth for several feet upstream. In this way the entire dam was constructed with the exception of a narrow strip near one end, which was left open during the construction to pass off the water underneath the structure. Then a row of iron pins (made of pipe and pointed on the end) was driven and willow branches and straw thrown in so as to wedge against these pins and then rock and earth in sacks and otherwise were thrown in to form a matting.



Temporary Dam Nearing Completion.

After this gap was closed the water rose rapidly until it nearly flowed over the dam, when a big section of the gravel bed slipped out from underneath and the water sank to its original level. This gap was then closed in the same manner as the first opening, and the water again began to rise, only to have another section give way. The same procedure was again followed and, besides, a considerable bank of earth was formed on the upstream side. This time the water overflowed the dam for about ten hours, when another break occurred, each break being in a different place. When this has been patched up (they are working on it now) and the dam breaks once or twice more, they will have patched the whole length and yet not be sure that it will hold. The contractor, who is obliged to furnish a stable dam, has already exceeded his contract price. If the sheet piling had been driven to a proper depth he very likely would have avoided this trouble and would be money ahead, where now he is a loser because he did not take proper precautions. The dam is 4 to 5 ft. high and nearly 500 ft. long.

Yours truly, EDWARD BALBACH.

DAYTON, OHIO, Oct. 27.

WATER METERS have proved decidedly economical at a Philadelphia factory, where about 3,000,000 cu. ft., were used last year. At the regular meter rate this supply cost $904.85. Without meters the charge for boiler feed water only would have been $1,500 on the usual rating of $2 per horse-power, and about $400 would have been charged under other items in the schedule.